A MIXED METHODS STUDY OF PRINCIPALS' EXPERIENCE

USING DATA ANALYTIC TOOLS IN HAWAIʻI

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ABSTRACT

The potential benefits of the growing amount of available educational data have not been fully realized, especially for principals, who play a key role in deriving insight from data to inform school improvement. The purpose of this mixed methods study was to describe experiences of principals using data analysis tools in a K–12 system. With a two-phased explanatory sequential design anchored in activity theory, the researcher investigated the types of data and tools used by principals, how they were used, and what factors influenced such use. Data were collected through an online survey administered to all public school principals in Hawai‘i as well as a think-aloud protocol and semistructured interviews with a smaller group. Responses showed that principals used school process and perceptual data on a more frequent basis than student learning or demographic data despite the greater investment in tools for the latter. Factors that influenced use included: (a) data characteristics, such as quality and quantity; (b) school organizational characteristics, such as professional learning and time; (c) computer system characteristics, such as integration, accessibility, user interface, and functionality; and (d) user characteristics, such as disposition and skills. Trends emerged around the ways the tools were not as useful or usable because of a lack of the following: data visualization, interactive dashboards, customization, and technological advancements. Thus, school district administrators are urged to increase investment in advanced analytic tools that can support a greater variety of data types and ways to integrate data systems. Findings may be used by tool designers and developers to improve tools. Structured time and training are also needed to support users. Additional research is suggested for improved understanding of the mediating role of evolving digital tools in analysis activity in order to help educators leverage greater insights.

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CHAPTER 1. INTRODUCTION

In the era of school accountability, an unprecedented amount of student achievement data has become available to school leaders. As primary decision-makers for their schools, principals are expected to analyze these data and use their conclusions to inform everything from allocating resources to promoting instructional strategies (Siemens et al., 2011). "Data use lives and dies in the principal's office because principals are in contact with so many aspects of district data use—their own data use, their teachers' data use, and their district's data use" (Wayman, Cho, & Johnston, 2007, p. 55). District leaders have increasingly invested in a new generation of data analytic tools to support this work (Murali, 2014), but research to understand the process, context, and consequences of these efforts is still lacking (Coburn & Turner, 2011). Digital tools have played a vital role across many industries in processing Big Data (Zhu et al., 2016) on interactive platforms that allow users to explore their own questions, filtering data by various dimensions and looking for longitudinal trends over multiple years (Means, Padilla, & Gallagher, 2010). As visualization tools gain popularity in the field of education, a better understanding of the ways educators interact with such tools is necessary (Marker, 2016; U. K. Pandey & Pal, 2011; Williams, 2011). This chapter includes the problems surrounding school leaders' use of data analytic tools, the research questions, and definitions of the terminology to be used in this study. The methodology and research design described in subsequent chapters have been informed by the adoption of activity theory as the framework to understand the mediating role of technology in data analysis activities. Activity theory was used throughout the study from the formation of the research questions through the interpretation of the findings.

Statement of the Problem

Because of technological advances and recent educational policies, more data is available now than ever before; but the potential benefits of data usage have not been realized (Murray, 2014; Schildkamp, Poortman, Luyten, & Ebbeler, 2016). Much of the current work with data would be difficult if not impossible without sophisticated data systems in schools, but regardless of how sophisticated the tools become, agency for change still lies in people and not the tools themselves (Cho & Wayman, 2014). Data use among educators remains fragmented in districts where vision and support plans are lacking (Wayman, Cho, Jimerson, & Spikes, 2012). School leaders play an essential role in data informed decision-making at schools because of their unique position to impact systemic improvement (Jimerson, 2014). More research is needed to understand school leadership and digital data work in order to make sense of contemporary schooling (Selwyn, Henderson, & Chao, 2015). Previous literature has focused more on teacher data use (Jimerson, 2016; Schildkamp et al., 2016; Wayman et al., 2012) with fewer studies illuminating the data analysis practices of principals (Marker, 2016).

Data use can be hindered by a number of factors, such as limitations in available tools (Setlur, Battersby, Tory, Gossweiler, & Chang, 2016), lack of data literacy skills among educators (Cosner, 2012; Murray, 2014), and lack of district support (Cho & Wayman, 2014). The use of data tools in public education has also raised some concerns about privacy now that users can filter data in more ways, making identifying potential confidentiality issues more difficult (Lysy, 2013). In addition, user control also means that the developer has less control over the story told to the user and less understanding of what meaning users glean from their experience (Lysy, 2013). Because of the mediating role played by the designers of the tools, data

analysis in the modern era has been described by some researchers as a "complex and compromised element of contemporary schooling" (Selwyn et al., 2015, p. 14). The lack of research on emerging data analytic tools has left the educational community with powerful tools but a shallow understanding of user experience with these tools and the impact of their use (Schildkamp & Kuiper, 2010). In order to support principals in the use of data and provide them with quality training, gaining more knowledge about the factors that promote or hinder data use with such tools is necessary (Schildkamp et al., 2016).

Purpose

The purpose of this mixed methods study was to understand the experience of principals using digital data tools in a K–12 system. In learning more about the types of tools and data used, how they were used, and what factors influenced principals' use, this research served as a needs analysis. Researchers have pointed to the key role of principals as influential change agents responsible for not only analyzing data but also modeling the practice and supporting it throughout their schools. Using data to inform decisions has been touted as an essential element separating successful school reform from unsuccessful (Bernhardt, 2013b). Situated in the context of an era of broader accountability in education, new tools have been funded to support this important practice in the midst of a deluge of data points; but little research has been done on the impact of those tools. The tools themselves can shape a principal's experience considerably in a way that might empower or hinder users in achieving their goals for data analysis. In order to support principals effectively, system leaders need to understand their interactions with data as well as the technology that provides access to that data (Marker, 2016). By triangulating results found in quantitative and qualitative research, this researcher examined the experiences of

principals using digital data analysis tools and identified tensions that may exist between theory and practice.

Research Questions

The main research question driving this study was the following: How do principals perceive their experience with data analytic tools in a K–12 system? It was divided into four subquestions in order to examine each salient issue and increase specificity:

RQ1. What types of data and data analytic tools do principals use?

RQ2. How do principals use data analytic tools?

RQ3. What factors influence principals' use of data analytic tools?

RQ4. How do principals describe the impact of data analytic tools on their work?

Significance of the Study

This study, like other empirical studies in education, has the potential to inform the practice of educators and district leaders, policy makers, and researchers (Creswell, 2008a; Randolph, 2008). Educational research is well suited to uncover effective strategies, techniques, and practices of teachers and administrators that can improve professional practices in the field (Worthington, 2010). Because the research is local in scope, local stakeholders may gain valuable insights to improve practice, increase training, enhance district support, and improve computer systems (Cho & Wayman, 2014).

Policy makers can benefit from a deeper understanding of the way educators actually use data analytic tools in school improvement efforts because studies have shown that the overemphasis on accountability data has often come at the cost of using data for instructional purposes (Schildkamp et al., 2016). The Every Student Succeeds Act, which is current federal

law, requires states to provide a public data dashboard with performance, growth, and subgroup data along with a summative determination annually (U.S. Department of Education, 2015). Policy makers can benefit from a deeper understanding of the user experience with such dashboards because legislative priorities have a direct impact on funding and product development.

Researchers can also benefit from the findings in this study because it adds to the existing body of knowledge in educational technology. Randolph's (2008) summary of common questions asked in the field of educational technology research included the following:

1. How do users interact with educational technology?
2. What are the effects of a given technology on practice?
3. What can be learned by studying users?

The findings of this study have been situated in these questions and have added to existing knowledge of educators interacting with technology to enhance their work and ultimately improve outcomes for students. The findings have also added to what is known about factors impacting data use tools in education and the applicability of activity theory as a useful framework to describe and understand technology use.

Conceptual Framework

Introduced into the field of human–computer interaction in the late 1980s, activity theory has been used to understand the role of tools in everyday life and how they shape people's interaction with information (Clemmensen, Kaptelinin, & Nardi, 2016; Kuutti, 1996; Nardi, 1996). Activity theory has provided a structure to explore the relationships that exist in purposeful, mediated, human social activities (Kaptelinin & Nardi, 2006). Building upon the

work of other researchers in education and human–computer interaction (Allen, Karanasios, & Slavova, 2011), the researcher applied activity theory in this study to frame the relationship between the subject—the school leader—and the object—engagement in data analysis activity—using digital tools to gain insight. The ultimate outcome of motivating principals to engage in data analysis activity is the transformation of an insight into a decision that will have an impact on school improvement (Bernhardt, 2013b). Tools mediate the relationship between a subject and the object of their activity (Kuutti, 1996); in this case the technology serves as a mediating tool between principals and the data they are analyzing. The community component of activity theory situates work activity within a broader context (Allen et al., 2011), and the community of school leaders includes their school (Wayman et al., 2012) as well as their broader district community (Dougherty, 2015). Major mediating factors between school leaders and their community include the systems and policies that exert considerable influence on all aspects of data use in education (Briggs, Cheney, Davis, & Moll, 2013; Datnow & Park, 2014; Larkin, 2010; Mandinach, Honey, & Light, 2006). Once the relationships were framed, activity theory was used to guide the formation of research questions and conceptualize the relationships in the findings. More detail about this conceptual framework appears in Chapter 2.

Summary of Methodology

In order to improve understanding of principals' experiences, a mixed methods study was conducted. This approach was selected so that the limitations of one method could be offset by the strengths of the other (Creswell & Plano Clark, 2011). Qualitative research can describe the way people construct their world as well as interpret their experiences and the meaning they attribute to them (Merriam & Tisdell, 2015). The strength of quantitative research is the

generalizability of results to a larger population (Creswell & Plano Clark, 2011). By collecting both, individual perspectives will not be lost in the larger quantitative data, nor will general trends from a larger population be lost because only a few cases have been studied (Creswell & Plano Clark, 2011). The mixed methods approach was selected after considering the recommendations of other researchers in the field. While studying the data use of educators, Schildkamp, Poortman, Luyten, and Ebbeler (2016) called for further studies to determine what actually happens in the school when educators engage in data use and specifically recommended a mixed methods approach to combine quantitative data with more generalizable results about the factors influencing data use and qualitative data to more deeply understand practice.

Two distinct phases of data collection and analysis were used in this study as a part of the explanatory sequential design (Creswell & Clark, 2011). In the first phase an online survey was sent to all 256 public school principals in the Hawai‘i Department of Education (HIDOE) to collect quantitative data about the population’s experience with data analytic tools and to identify participants for the second phase. Analysis of this quantitative data informed the subsequent phase of qualitative data collection in two major ways. First, the data from the larger population were analyzed to identify a smaller population of six principals who indicated they would be willing to participate in Phase 2. From the list of volunteers, the purposive sample was selected to represent variation in demographics to the extent possible. The researcher then conducted document analysis of the publicly posted school Academic Plans of the six principals who volunteered to participate in the qualitative data collection in order to understand the context of their schools, the goals they had set, and their indicators of progress prior to the semistructured interview session. Phase 2 consisted of a 30-minute think-aloud and observation immediately

followed by a 30-minute semistructured interview. Collecting both qualitative and quantitative data provided a more complete understanding of the research problem than either approach could alone (Creswell & Clark, 2011). The design is visualized in Figure 1 and described in more depth in Chapter 3.

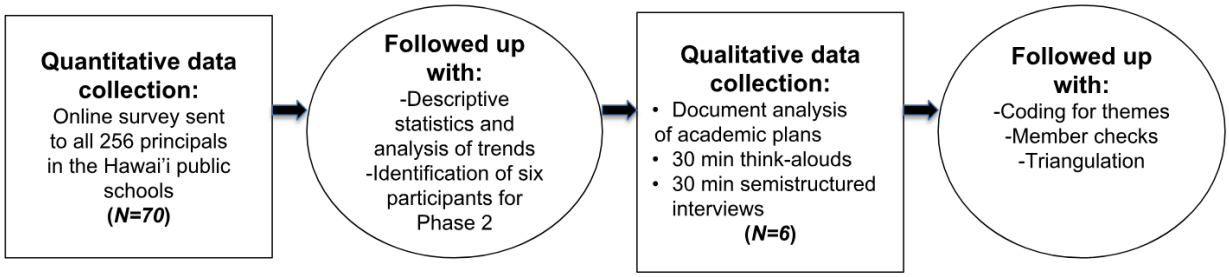

Figure 1. Explanatory sequential design of this study

Role of the Researcher

Factors impacting the researcher's role in a study included the level of participation, amount of time spent in the setting, and the extent to which the participants were informed about the study (Marshall & Rossman, 2014). Considering these factors, the researcher took the observer-as-participant stance in order to establish rapport without becoming involved in the actions of participants (Ary, Jacobs, Irvine, & Walker, 2013). In this role, the researcher's activities were known to the group, and the level of information revealed was controlled by those investigated (Merriam & Tisdell, 2015). The benefit of conducting research transparently is that asking structured questions to elicit targeted information is easier, but a potential drawback is that when people know they are observed, they may also behave in ways different from their normal behavior because the observer destroys some of the naturalness of the setting by her or his presence (Ary et al., 2013). Interviews can be impacted by the level of rapport between the

researcher and those interviewed (Merriam & Tisdell, 2015), a factor important in this study because the researcher was also an employee of the district under study.

At the time of the study, the researcher had worked in the Hawai‘i Department of Education for 11 years, most recently in the position of a School Renewal Specialist in one of the 15 Complex Areas. Under the supervision of the Complex Area superintendent, responsibilities included supporting 14 principals on a regular basis by organizing monthly networking sessions and providing individual training as needed. One potential benefit of status as an employee was that participants might have increased trust in the researcher, but a drawback could also have been perceived pressure to answer in a certain way instead of answering honestly. Steps to mitigate perceived pressure on participants included highlighting the voluntary and confidential nature of the survey in the description given to participants during Phase 1 and reiterating it in Phase 2. As suggested by Merriam and Tisdell (2015), the researcher practiced the skills of maintaining neutral body language to avoid encouraging certain responses in face-to-face contact during interviews and observations.

Limitations

In balancing ambitions with the pragmatic realities of conducting the study, the researcher limited its scope. The setting was specific to the single statewide school system unique to the state of Hawai‘i. The small and purposive sampling made the findings less generalizable to a larger population. The dual role of the researcher as a fellow employee of participants was also a limitation because the researcher was one of the primary instruments for data collection and analysis. Developing a meaningful understanding of human experience is impossible without considering how that experience is affected by the researchers’ values and

beliefs (Ary et al., 2013). The researcher acknowledged her positive bias toward using data analysis tools, which may have impacted such things as the questions explored and the themes identified during analysis.

In selecting what types of data to collect, the researcher weighed the advantages and disadvantages of each data collection method (Creswell, 2008b). This study involved several sources of self-reported information, which was limited by the ability of respondents to accurately remember their experiences and their willingness to answer questions truthfully. An online survey tool was selected because it provided an inexpensive and efficient form of data collection, but not all participants might have been equally comfortable navigating online surveys, possibly affecting the representation in the sample data (Creswell, 2008b). Other limitations presented with the chosen data collection methods might have accompanied the nature of the think-aloud protocols, which can be obtrusive and cause participants to act differently while thinking aloud about their actions. Limited short-term memory capacity for talking and attending at the same time as well as hearing one's own voices can actually cause learning to occur as a result of thinking aloud and thus alter the participant's experience. In addition, the researcher's influence through verbal or nonverbal cues may alter the naturalness of the setting (Branch, 2013). Observations as a data collection method are limited because humans have selective perception (Merriam & Tisdell, 2015). The presence of the researcher in the observation has some effect on the environment, so the researcher must identify those effects and account for them (Merriam & Tisdell, 2015). Based on the limitations of specific data collection methods, the researcher selected a mixed method approach and was cautious in generalizing to larger populations or other contexts.

Definition of Key Terms

Following are the key terms used in this study.

Analytics. Information resulting from data analysis, a term not as widely used in the field of education as in other industries (Marker, 2016).

Big data. Information substantial in volume, highly varied, and collected in real time can be extended in scale and related to other datasets (Williamson, 2015).

Dashboard. Visual display of the most important information needed to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance (Schwendimann et al., 2016).

Data. Information systematically collected and organized to represent some aspect of schools (Schildkamp et al., 2016).

Data analytic tools. Technologies that support the capture, management, processing, and analysis of data (Kumar, Sujatha, & Chandrakumar, 2017).

Data informed practice. An ongoing, inquiry-based process that incorporates multiple pieces of evidence (e.g., classroom assessments, standardized test data, interest inventories, and parent information among others) to identify obstacles to student or organizational success and subsequently implements strategies to better serve the academic, social, and emotional needs of individual students and groups of students (Jimerson, 2016).

Data use. Actions of educators as they collect data, organize and analyze them, and draw meaning from them to inform practice (Wayman et al., 2012).

Practice. More or less coordinated, patterned, and meaningful interactions of people at work; the meaning of and the medium for these interactions is derived from an activity or social system that spans time and space (Spillane, 2012)

Principal. In Hawai‘i, a principal is a school-level educational officer with a valid Hawai‘i State School Administrator Certificate, who serves as the leader of a school (Office of the Superintendent, 2017).

Summary

The purpose of this study was to increase understanding about the ways principals use data analysis tools, the manner in which those tools influence their practice, and the potential systemic improvements needed. This mixed methods study included two distinct phases. During Phase 1 quantitative data was collected through a 15- to 20-minute online survey sent to all principals in the district under study. Descriptive statistics were applied to the information gathered from the survey to identify trends and inform the questions in Phase 2 as well as the selection of interviewees. Six respondents who indicated a willingness to participate in Phase 2 and represented demographic variation to the greatest extent possible were asked to participate in the think-aloud and semistructured interview. Each of the six principals participated in the 30-minute think-aloud protocol and observation in which they demonstrated how they used various tools, followed by a 30-minute semistructured interview about their experiences. The data were analyzed and coded for emerging themes in alignment with the research questions and theoretical framework.

A synthesis of related literature on using data in schools, current tools that support data analysis, user experience research, and the history of activity theory appear in Chapter 2,

followed by a more detailed account of the methodology in Chapter 3. The findings are presented in Chapter 4, followed by a discussion of those findings and limitations in Chapter 5. The appendices include a copy of the consent form, survey tool, think-aloud and semistructured interview protocol, and permissions obtained for use of materials.

CHAPTER 2. REVIEW OF LITERATURE

Three key domains relevant to this study have been examined in this chapter: data-informed decision-making in schools, technology that supports analysis of educational data, and user experience when interacting with digital data platforms. A description of recent policies that have resulted in the expectation for school leaders use a variety of educational data to inform their decisions appears first, followed by the emergence of digital tools to support users interacting with data. User experience, particularly that of school administrators trying to generate insight from data analysis, appears next. The chapter concludes with an explanation of activity theory presented as a framework from which to understand the school administrator's experience with digital data visualization tools aimed at gaining insight to support school improvement.

Using Data in Schools

A general lack of understanding surrounds data use in education (Datnow & Park, 2014; Jimerson, 2014), but it has been broadly defined as any information that helps educators, schools, and districts do their jobs (Deike, 2009). The terms *data-driven decision-making* and *data-based decision-making* have historically appeared in publications in this field, but the current trend is to use the term *data-informed decision-making* to emphasize the manner in which data informs the working knowledge of humans without driving them (Murray, 2014; Wayman, Snodgrass Rangel, Jimerson, & Cho, 2010). Schildkamp and Kuiper (2010) conducted a qualitative exploratory study examining data use at six high-performing Dutch schools and concluded that teachers and school leaders used data for a variety of purposes; a common trend, however, was that data use was underutilized for informing decisions. Many studies have confirmed that the

mere availability of data and analysis tools does not guarantee usage (Kowalski & Lasley, 2009), increased knowledge (Selwyn, 2015), changes in practice (Wayman & Stringfield, 2006), or improvement in outcomes (Schildkamp & Kuiper, 2010). The complex issues surrounding data use appear in the following sections on the history of the accountability movement, the types of educational data, the role of school leaders, and data literacy. Opening with the policies of the federal government is essential because of the key role they have played in shaping the reasons for collecting data, the types of data collected, and the culture of data analysis (Halverson & Shapiro, 2012).

Policies Influencing Data Use

The current climate of education policy and accountability at the federal level derived from the original version of the Elementary and Secondary Education Act (ESEA) passed in 1965 in the United States (Edmonds, 2016). The ESEA was originally designed to address educational inequalities in subgroups by providing targeted federal aid and programmatic funding in exchange for increased federal expectations for local education agencies. Over subsequent decades the law was updated several times, most famously in 2001 when President George W. Bush signed the No Child Left Behind Act (NCLB) with an emphasis on incentives and sanctions for schools tied to annual student outcomes (Chapman, 2007). When NCLB went into effect, all K–12 public schools were required to implement student information systems to track student achievement data. Halverson and Shapiro (2012) argued that even if classrooms remained relatively immune to new technologies during that time, school management personnel had no choice but to adopt data systems to track assessment data required by NCLB. They described this driving force as a culture of accountability:

> The accountability logic is grounded in (a) clearly defining the common standards towards which learning should be directed, (b) developing assessments that measure the degree to which education systems achieve standards, and (c) providing feedback to schools on the gaps between current and expected achievement outcomes. Accountability logic guides the design of new tools and practices that, in time, are routinized in ways that establish an accountability culture. (Halverson & Shapiro, 2012, p. 9)

"What gets measured gets done," a maxim popular during the era of NCLB, held true as school districts invested heavily in tools like student information systems, learning management systems, and computer-adaptive assessments to generate reports (Halverson & Shapiro, 2012; Kowalski & Lasley, 2009). The types of technology that supported monitoring progress toward summative outcomes were prioritized over types of technology that helped teachers inform daily instructional decisions (Halverson & Shapiro, 2012).

The contemporary discussion of data use has been dominated by this accountability reform agenda with the expectation that all educators use data to improve practices in ways that produce measurable outcomes with an emphasis on standardized test scores (Datnow & Park, 2014; Halverson & Shapiro, 2012; Means, Padilla, DeBarger, & Bakia, 2009). When the federal government designed the $4.35 billion dollar Race to the Top Grant in 2009, one of the four core reforms required in the application was to build data systems that measured student success and informed educators about how they could improve instruction (U.S. Department of Education, 2009). States were awarded points for their plans to ensure that data from a statewide longitudinal data system were accessible and that the data supported decision-makers in continuous improvement efforts in such areas as policy, instruction, operations, management,

resource allocation, and overall effectiveness (U.S. Department of Education, 2009). The Race to the Top requirements around the use of data to improve instruction included the following:

1. Increase the acquisition, adoption, and use of local instructional improvement systems that provide teachers, principals, and administrators with the information and resources they need to inform and improve their instructional practices, decision-making, and overall effectiveness;
2. Support participating Local Educational Agencies and schools that are using instructional improvement systems in providing effective professional development to teachers, principals, and administrators on how to use these systems and the resulting data to support continuous instructional improvement; and
3. Make the data from instructional improvement systems, together with statewide longitudinal data system data, available and accessible to researchers so that they have detailed information with which to evaluate the effectiveness of instructional materials, strategies, and approaches for educating different types of students (e.g., students with disabilities, English language learners, students whose achievement is well below or above grade level). (U.S. Department of Education, 2009, p. 8)

Critics of standardization argued that Race to the Top narrowed the focus of educational goals and energies of school personnel as a result of outcomes deemed important at a federal level (Onosko, 2011). Every Student Succeeds Act (ESSA), the most recent act, was passed in December 2015 and has been praised for providing states more power to set their own localized measures of success; but the federal government's influence in shaping accountability systems at all levels cannot be denied (Darling-Hammond et al., 2016; Klein, 2015). Although states can

select their tests, standardized testing is federally required in reading and math for all public-school students in Grades 3–8 and once in high school along with required science testing at least once in elementary, middle, and high school (Sharp, 2016).

States were required to report high school graduation rates along with growth and proficiency scores disaggregated by the following demographic subgroups: major racial groups, economically disadvantaged, disabilities, English proficiency status, gender and migrant status (Sharp, 2016). ESSA required states to give each school a summative determination in at least three categories, including comprehensive support and improvement, targeted support and improvement, and continuous improvement, and provide a public data dashboard or report card to increase transparency (U.S. Department of Education, 2015). The Trump administration has rolled back some of the Obama-era regulations, reducing the template of the ESSA plan by six pages and no longer requiring states to provide details explaining, for example, why a state might choose a minimum subgroup size above 30 for accountability reporting (Klein, 2017). In summary, the types of data, organization of that data, and the motivation for analyzing have been often politically driven by the broader system, where data is being used "on educators" as well as "for educators" (Datnow, Park, & Wohlstetter, 2007; Selwyn, 2015).

Schildkamp, Karbautzki, Breiter, Marciniak, and Ronka (2012) developed a data use framework emphasizing the influence of policy on all facets of data use. The enablers and barriers they identified were organizational characteristics, such as time and training; data characteristics, such as data quality and tools; user characteristics, such as attitude and skills (see Figure 2). In case studies across five countries, they found that national policies influenced data characteristics through the types of data that were available and influenced users who felt

pressure from external evaluation and public presentation of school performance reports. Schildkamp et. al (2012) delineated three types of data-driven decision-making used for stakeholder and student learning: data used for (a) school development purposes, such as monitoring school goals; (b) accountability purposes, such as meeting the accountability demands of evaluation; and finally (c) instructional development, such as adjusting instruction.

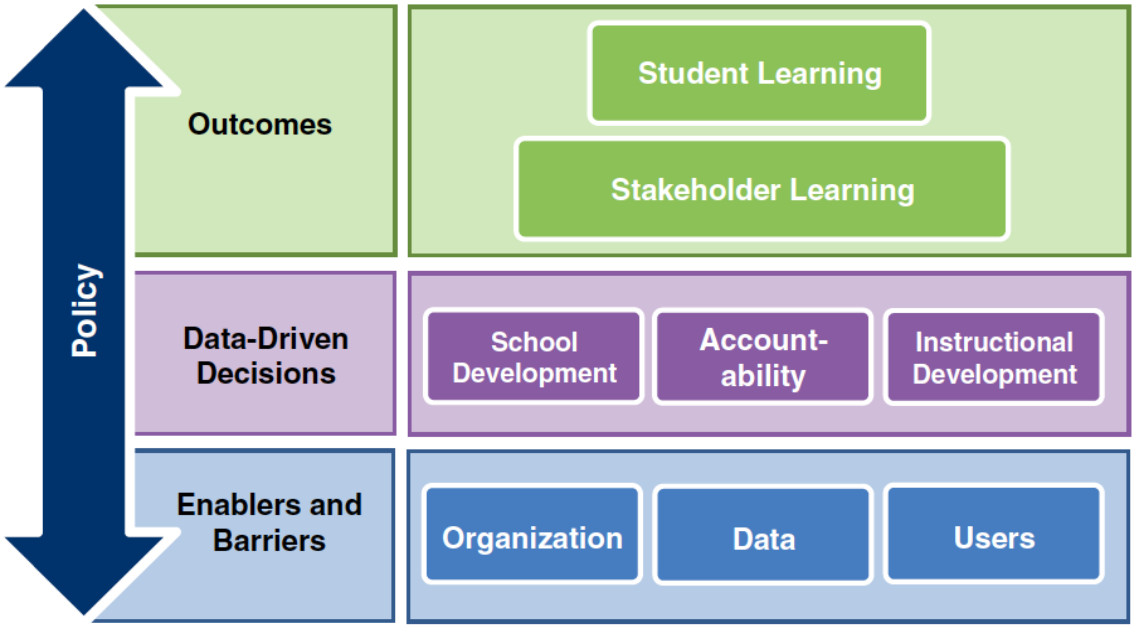

Figure 2. A data use framework. From "The use of data across countries: Development and application of a data use framework," by K. Schildkamp et al., 2012, *IFIP Conference on Information Technology in Educational Management, 400,* p. 33. Copyright 2012 by K. Schildkamp et al., See Appendix A for permission to reprint.

Hawai'i Department of Education System Context

This study was situated in the Hawai'i Department of Education (HIDOE) which is unique as the only statewide centralized school system in the United States. The HIDOE includes 256 public schools and more than 169,000 students (Office of the Superintendent, 2017). The state has been subdivided into 15 Complex Areas located across six main islands. Each Complex Area is a geographic region consisting of two to four complexes, typically including a single

high school and the intermediate and elementary schools within its attendance boundary (Office of the Superintendent, 2017). The trilevel system of support refers to the partnership between the state office, the Complex Area offices, and the schools-level offices. The names of the islands and Complex Areas appear in Table 1.

Table 1. *Complex Areas and Islands in the Hawai'i Department of Education*

Statewide School District: Hawai'i Department of Education (HIDOE)	**6 Main Islands:**	**15 Complex Areas:** (Each consists of 2–4 complexes, named after the high schools in that geographic region)
	1. Hawai'i (Big Island)	1. Hilo-Waiakea 2. Kau-Keaau-Pahoa 3. Honokaa-Kealakehe-Kohala-Konawaena
	2. Kauai	4. Kapaa-Kauai-Waimea
	3. Maui 4. Molokai 5. Lanai	5. Baldwin-Kekaulike-Maui 6. Hana-Lahainaluna-Lanai-Molokai
	6. Oahu	7. Farrington-Kaiser-Kalani 8. Kaimuki-McKinley-Roosevelt 9. Aiea-Moanalua-Radford 10. Leilehua-Mililani-Waialua 11. Campbell-Kapolei 12. Pearl City-Waipahu 13. Nanakuli-Waianae 14. Castle-Kahuku 15. Kailua-Kalaheo

Full-time school staff comprises 10,984 teachers statewide, 157 librarians, 611 counselors, and additional support staff (Office of the Superintendent, 2017). The student population is diverse with the largest ethnic groups consisting of Hawaiians and Filipinos (Halagao, 2016). Hawai'i is home to the largest percentage of Asian Americans and multiracial Americans of any state in the Union (Krogstad, 2015). On the most recent National Assessment

of Educational Progress (NAEP), Hawai‘i students in Grades 4 and 8 scored below the national average in reading, math, and science assessments (Office of the Superintendent, 2017).

In August 2010, HIDOE applied for the competitive federal Race to the Top grant and was awarded $75 million over four years along with a flexibility waiver to create its own accountability system in place of No Child Left Behind (Hawai‘i State Department of Education, n.d.). The five major points of Hawai‘i’s Race to the Top plan included (a) establishing high-quality college- and career-ready standards and assessments; (b) improving longitudinal data collection and use; (c) cultivating, rewarding, and leveraging effective teaching and leading; (d) providing targeted support to struggling schools and students; and (e) aligning organizational functions to support reform outcomes. Funding was used to enhance the Longitudinal Data System (LDS) so that teachers and administrators could have access to a web-based dashboard generating longitudinal data reports that apply diverse indicators to more than two decades of individual student records (Hawai‘i State Department of Education, n.d.). This reporting tool offers hundreds of metrics and reports for the purpose of monitoring progress at the classroom, school, and system levels (Hawai‘i State Department of Education, n.d.).

The LDS was launched in Hawai‘i during the 2010–2011 school year via an introduction to school principals and HIDOE state-level leaders. Training initially focused on how the data were defined and how to investigate inaccuracies. Early on, administrators shared concerns about the reliability and timeliness of data, data quality issues, privacy, and time constraints. As a result of participants’ questions and concerns, the trainers better understood users’ needs, and modifications were made to the tools based on user feedback (Bush et al., 2014). The Hawai‘i Data eXchange Partnership (DXP), managed by the University of Hawai‘i in partnership with

HIDOE and other state departments, was the recipient of a three-year federal grant that began in 2012. The funds were used to build the LDS and increase data use by expanding the training to teachers. An additional federal grant was issued in 2015 with a focus on cross-agency partnership, data use for instructional support, and gathering data for college and career readiness indicators (Hawai‘i Department of Education Data Governance and Analysis Branch, 2018); but no permanent funding has been put in place beyond the end of 2019, when the federal grant expires. From 2016 to 2018, the overall use of the LDS in the HIDOE increased across the system from 75,000+ logins per month in April 2016, to 300,000+ in April 2018 as shown in Figure 3.

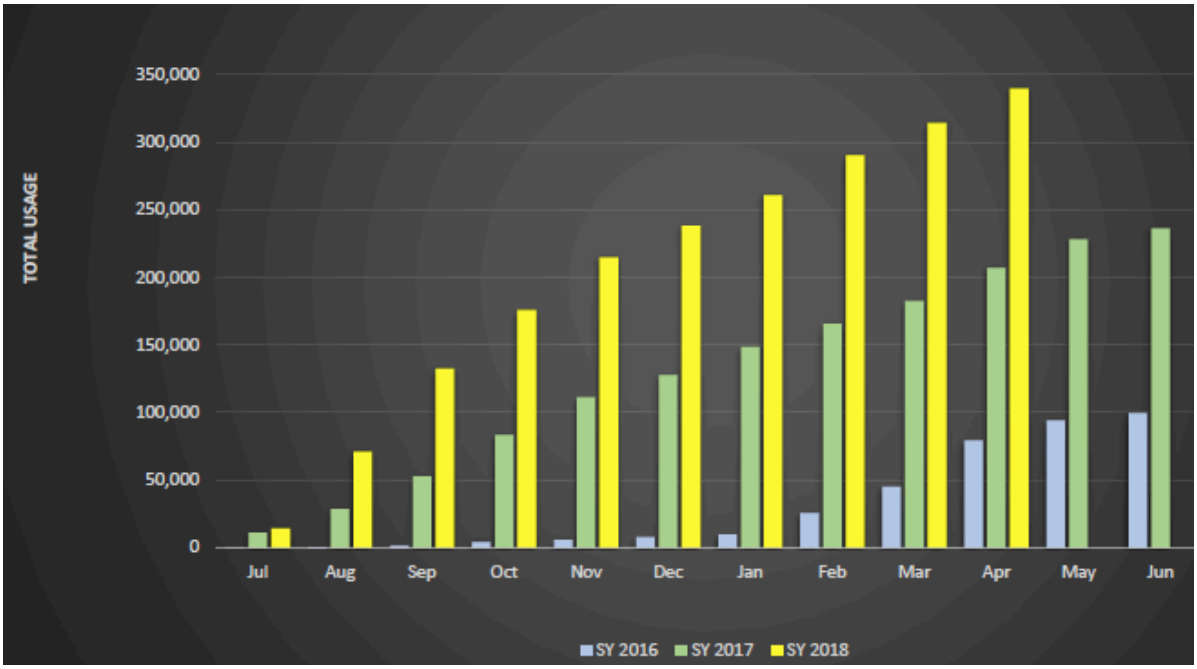

Figure 3. Total instances of logins on Longitudinal Data System over three years (Hawai‘i Department of Education Data Governance and Analysis Branch, 2018).

As a role group, principals increased in frequency of log-ins on the LDS from an average of seven times per month to 9.3 times per month with 229 unique log-ins by the 256 principals in

the HIDOE system as shown in Figure 4. Although the principal role group increased use of the LDS, they did not increase as much as the vice principal or counselor role group, members of which achieved a higher average number of logins each month.

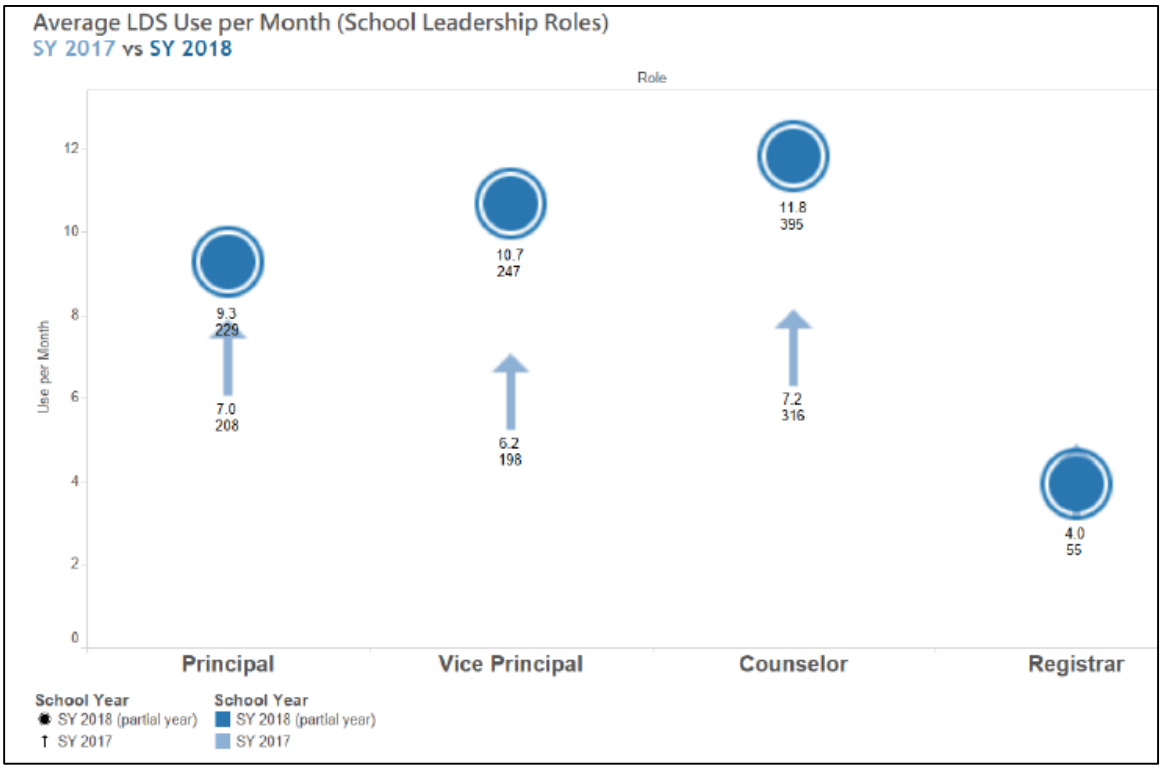

Figure 4. Average LDS use per month by leadership role (Hawai‘i Department of Education Data Governance and Analysis Branch, 2018).

In addition to the LDS system, the Hawai‘i Department of Education purchased a Tableau license for each Complex Area and coordinated a specialized training session to familiarize staff members with the software. A small group of users in those Complex Areas formed a user group to share knowledge and skills (Borkosky et al., 2017). In June 2017, Hawai‘i received the Newman Award for State Innovation for impactful improvement efforts, including focus on school improvement, educator support, development of a comprehensive

longitudinal data system that allowed educators real-time access to data, and investment in data literacy through the formative assessment–data team initiative.

Motivation for Data Analysis

In activity theory, a motive is an object that meets a particular need of the subject (Kaptelinin & Nardi, 2006). Bernhardt (2013b) framed data analysis as an activity in which educators engage for the purpose of systemic improvement. Several studies have shown that educators perceive a distinction between official compliance data mandated at the school and unofficial data that they generate and want to use (Selwyn et al., 2015). Motivation research has shown that behavior motivated by compliance is not optimal for learning (Deci, Vallerand, Pelletier, & Ryan, 1991; Zimmerman, 2011). The broad dichotomy of categorizing motivation as either internal or external has been replaced by a spectrum with behavior that is self-determined and motivated by choice on one end and controlled behavior motivated by compliance and the desire to please others on the other (Deci et al., 1991; Schunk & Zimmerman, 1997). The motivation source for engaging in a learning activity can fall anywhere along the spectrum of motivation sources, but studies have shown that internal motivation characterized by self-initiation, perseverance, and engagement in metacognition leads to increased learning (Pintrich, 2003; Pintrich & Schunk, 2002; Zimmerman, 2011). Educators have distinguished between data analysis motivated by compliance and data analysis they find useful; thus, examining the context fostering that perception may be important.

> Simply stated, motivation, performance, and development will be maximized within social contexts that provide people the opportunity to satisfy their basic psychological needs for competence, relatedness, and autonomy. Opportunities to satisfy any of these

> three needs contribute to people's being motivated (as opposed to amotivated). (Deci et al., 1991, p. 4)

For example, increasing the amount of positive feedback given to educators as they engage in data analysis could enhance their perceived competence, or making stronger connections to goals and interests and enjoyment could increase a person's sense of relatedness and thus their motivation to engage in such activity (R. M. Ryan & Deci, 2000). Considering the sources of motivation in this user experience (UX) study is important because both UX as well as activity theory frameworks encompass motivation-level needs (i.e., why people do what they do) as well as action-level needs (i.e., how people do what they do) (Kankainen, 2002; Kaptelinin & Nardi, 2006).

Types of Educational Data

Educational data consist of a wide variety of information systematically collected, both qualitative and quantitative in nature, and categorized based on (a) the information source, such as data from assessments as opposed to data from observations; (b) the time frame, such as first-semester data; and (c) confidentiality and audience, such as data intended for school counselors as opposed to registrars (Dougherty, 2015). One widely adopted model includes educational data categorized into four types: demographic data, student learning data, school process data, and perception data, each explored below (Bernhardt, 2013b; Datnow & Park, 2014).

Demographic data. Schools typically gather considerable amounts of demographic data on an ongoing basis primarily through their student information systems. Demographic data establish the context of the school by describing characteristics of human populations with descriptive statistics on factors like socioeconomic status, ethnicity, attendance, and discipline

records (Bernhardt, 2013b). Demographics also describe the system as a whole with information on class sizes, years of teachers' experience by grade level, and information on subgroups of students. School personnel can use demographic data to reflect on the continuous school improvement question—Who are we?—and to disaggregate results by various demographic indicators to determine whether their programs and impact are equitable (Bernhardt, 2013b).

Student learning data. Information on what students know and are able to do can come from a variety of assessment types, including formative assessments, teacher-developed performance tasks, standardized testing data, and student-led assessments. Assessment data can be categorized as assessment for learning (e.g. diagnostic tests, screeners, and other classroom assessments), assessment as learning (rubrics, performance tasks, and other authentic assessments), and assessment of learning (benchmark assessments, standardized tests, grades, and other summative measures) (Bernhardt, 2013b). Ideally, schools adopt a balanced assessment approach that combines multiple measures.

Process data. Process data involve descriptions and evaluations of programs, quality of curriculum, and other structures that influence the instructional and organizational environment. By studying and analyzing the systems in place at schools, a deeper understanding of how schools do business can help identify areas of improvement. Bernhardt (2013b) has asserted that school process measures are the only measures over which schools have almost complete control as opposed to measures like demographics, over which local schools have no control.

Perception data. Perception data tell schools what students, staff, and stakeholders think about the about various aspects of the learning organization. These attitudes, beliefs, and views

are often assessed through a questionnaire, focus group, interview, or self-assessment tool (Bernhardt, 2013b).

Using all types of data is important, but the actionable insight lies in the connection and relationships across multiple data types. Because various types of educational data are often interconnected, best practice involves looking at the mutual relations of two or more types of data to reveal root causes before applying data to inform decisions (Bernhardt, 2013b; Darling-Hammond et al., 2016). Figure 5 is a Venn diagram showing the information gained from the intersection of multiple measures (Bernhardt, 2013b). Countless possibilities show what intersecting measures can tell a school, but an example of a possible two-way intersection might come from cross-analyzing demographics by perceptions to determine whether subgroups of students experience school differently. An example of a three-way intersection might come from cross-analyzing demographics by student learning and school process data to explore the impact of specific programs on subgroups of students as measured by the learning results of the subgroups. The intersection of all four data types has the power to help schools predict what needs to be done to best meet the learning needs of all students in the schools as measured by student perceptions and student learning results (Bernhardt, 2013b).

Unfortunately, studies have shown an overreliance on single measures of student achievement perhaps as a result of the political climate in education and the emphasis on test scores (Datnow & Park, 2014; Ehlert, Cory, Parsons, & Podgursky, 2014; Murray, 2014). Using a single test score to inform decisions can be misleading because of the numerous factors impacting test achievement, such as students taking the test seriously (Reeves & Burt, 2006).

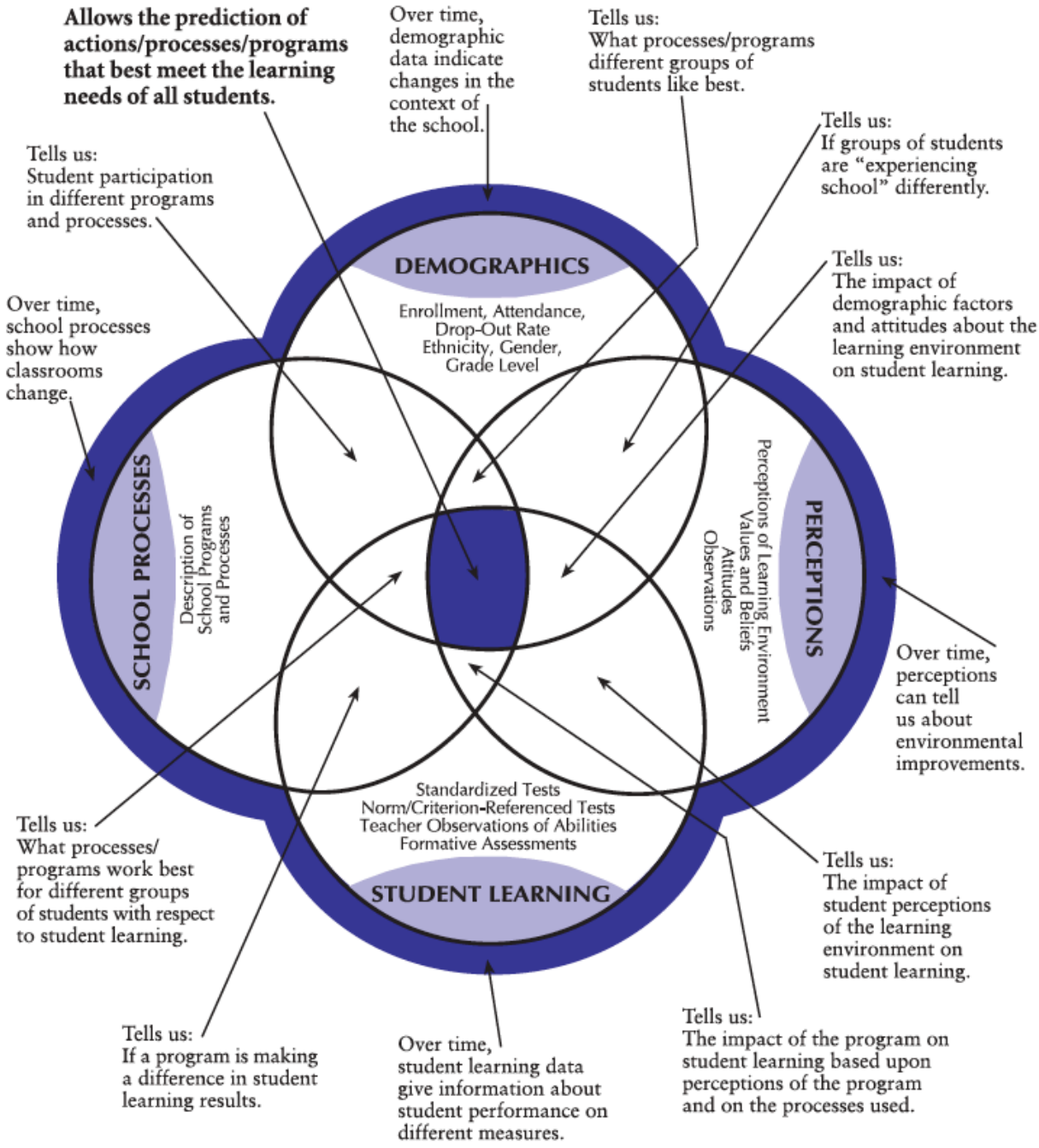

Figure 5. Multiple measures of data. From *Data Analysis for Continuous School Improvement* (4th ed., p. 17), by V. L. Bernhardt, 2018, New York: Routledge. Copyright 2018 by V. L. Bernhardt. See Appendix B for permission to reprint.

Documented barriers to triangulating multiple data sources include a lack of (a) integration of disparate data sources, (b) necessary time, and (c) technical skills to bring that data together (Conaway, Keesler, & Schwartz, 2015; Reeves & Burt, 2006). Murray (2014) cautioned against data analysis focused on only one type of data: "For the promise of data-informed decision-making to be realized, school leaders should begin to regularly employ intersectional analysis to gain insight into the variety of factors influencing school culture, teaching practices, and student learning" (p. 5). Teachers in focus groups across three regionally diverse schools echoed the key role of the principal in promoting the triangulation of multiple sources of data in a manner nonthreatening to teachers (Wayman & Stringfield, 2006). The key role of principals is detailed in the section below.

The Role of School Leaders in Data Use

One theme that has emerged in the literature is the importance of school leaders as central figures who serve as role models in their own data use, provide support for teachers, and set the culture surrounding data use on campus (Datnow & Park, 2014; Huguet, Marsh, & Farrell, 2014; Jimerson, 2014; Wayman & Stringfield, 2006). The terms *school leader*, *principal*, and *administrator* are often used interchangeably to refer to the leader of a school. The old profile of the school principal as simply a building manager is long gone, replaced as a result of the need for dynamic leaders who interact daily with a range of analytics in order to inform their leadership over a variety of improvement initiatives (Day, Gu, & Sammons, 2016; Leithwood, 2013; Wayman et al., 2012). Academic analytics is concerned with "the improvement of organizational processes, workflows, resource allocation, and institutional measurement through the use of learner, academic, and institutional data" (Siemens et al., 2011, p. 4). Extensive

surveys and case studies have shown that principals use data most often to set school improvement goals, monitor progress, evaluate staff, track resources, communicate the school's story to outside audiences, and meet accountability demands (Deike, 2009; Dougherty, 2015; Jimerson, 2014; Schildkamp & Kuiper, 2010). A qualitative case study involving leaders in data use in four school districts across California, Connecticut, and Texas showed the impact of school leaders who set specific measurable student achievement goals at the school level and modeled their own appropriate data use for the faculty (Datnow et al., 2007).

Teachers benefit from structured supports, such as collaborating in data teams, working with a data coach, and having dedicated time for data analysis (Lachat & Smith, 2005). In a mixed methods study of a large school district in Texas, teachers felt overwhelmed by the expectation to use data if their administrator did not provide dedicated time (Wayman et al., 2010) or training to develop their competence in data use (Schildkamp & Kuiper, 2010). Limited literature has been published on training teachers to develop data literacy, but preservice training has shown positive gains in skills and understanding data analysis (Dunlap & Piro, 2016); and the need for additional training has been well documented through questionnaires (Lazarová, Pol, Vašťatková, Trojan, & Bouda, 2015) and focus groups (Wayman et al., 2010). Training sessions must reach beyond how to access and use systems; they must show how to connect the information gained from data to future instructional practices (Wayman & Stringfield, 2006). Without proper training, teachers may determine the personal investment too steep and instead take only a compliance approach to data use (Wayman, Shaw, & Cho, 2017). Data coaches can serve as effective support to build teachers' capacity for data use (Lachat & Smith, 2005), but comparative case studies have demonstrated that administrators play an important role in shaping

the work of strong coaches and helping them navigate the political dynamics of schools (Huguet et al., 2014).

School leaders are vital in developing a shared vision of (a) what data are meaningful, (b) what expectations accompany their use, and (c) what facilitates a balance between data for accountability and data for improvement functions (Jimerson, 2014). Themes have emerged across studies, confirming that schools more effectively using data had supportive and enthusiastic leaders, who expressed the importance of data and established norms surrounding their use (Schildkamp & Kuiper, 2010); but schools where data use was seemingly less effective were characterized by a disconnect between faculty and administrator views of data along with poor communication (Wayman et al., 2010). Larger evaluative studies of districts have validated this trend of a fragmented districtwide vision for data use (Deike, 2009) and underutilized central offices that fail to provide the necessary training for principals to make sense of data or the technology systems they are required to navigate (Wayman et al., 2012). Central offices have often invested more in the tools than the training to support users, exemplifying an ineffective mentality: "If we build it, they will come" (Marker, 2016).

In a study of Hawai‘i public school principals' level of technology use and the meaningful integration of technology, Parker (2014) found that principals thought formal HIDOE professional development programs were much needed to systematically provide principals with technology training on topics like spreadsheets or databases. The study also revealed that the older the principals were and the longer they had been at their present school, the lower they scored on the scales for technology understanding and integration (Parker, 2014).

> Without addressing the need for support to principals who may be older or have served as a principal for an extended amount of time, the ability for technology to be successfully used by not just the principal, but by the entire school could be impacted. (Parker, 2014, p. 90)

Although principals were in need of training, Parker's (2014) random sampling of Hawai'i public schools' academic and financial plans revealed that no schools had set aside funds for professional development for principals related to technology use or implementation support.

Individual schools in the HIDOE have the autonomy to spend funds on principal training so those opportunities vary greatly from school to school. HIDOE has also made systemic efforts to provide technical supports through external partnerships (Suthers, Yukawa, & Harada, 2007) as well as internal training on targeted platforms. A federal grant newsletter for the LDS described the training launch in Hawai'i for school principals and state education agency leaders to garner buy-in for the school year 2010–2011 (Bush et al., 2014). Training was designed to introduce platform navigation, demonstrate the benefits of data access, receive important information about data quality and privacy, and address concerns specific to each unique audience. In the 2012–2013 school year, training was more systematically offered to teachers, but some principals elected not to dedicate time for teachers to learn the tools. As the gatekeepers to the learning of their staff, principals have the authority to support training or block training (Marker, 2016).

Data Literacy Challenges

Data have no meaning in and of themselves, and whether or not data become meaningful depends on the understanding of the people looking at them and the context for understanding

them (Datnow & Park, 2014; Mandinach et al., 2006). Many schools have collected large amounts of student data over the years that users have not been able to interpret, making them data rich but information poor (Murray, 2014; Wayman et al., 2004). A growing number of studies have documented the lack of data literacy skills among educators to formulate questions, select quality indicators, recognize patterns, and interpret results in order to develop a response (Cosner, 2012; Dunlap & Piro, 2016; Huguet et al., 2014). The term *data-literate leader* denotes someone who thinks about purpose, recognizes sound and unsound data, is knowledgeable about statistical and measurement concepts, and makes interpretation paramount (Earl & Katz, 2002).

Lack of preservice training (Reeves & Burt, 2006) and minimal district support (Bottoms & O'Neill, 2001; Leithwood, 2013) have often been cited as persistent challenges. Emanating from this need to enhance the quality of supports, a workgroup was convened in 2014, representing 14 states and Guam, to identify critical knowledge, skills, and behaviors needed by educators to use data effectively (SLDS Data Use Standards, 2015). In view of the complexity of the 59 standards developed by the workgroup, surveys and interviews among school administrators show an unsurprising enthusiasm to use data that is often tempered by a perceived lack of ability and self-confidence (Lazarová et al., 2015; Reeves & Burt, 2006). In addition to feeling ill-prepared, leaders in key roles also struggle with a lack of time amid administrator overload (Reeves & Burt, 2006), delayed access to relevant data, and data quality issues (Bernhardt, 2013b; Lachat & Smith, 2005). Even if tools exist to support administrators in combating these issues, leaders must possess the technical literacy to leverage those tools (SLDS Data Use Standards, 2015). The next section explores the evolution of tools that originated in the business intelligence sector, later adopted in the field of education to support data analysis.

Technology Tools

As the datafication of many aspects of the world continues to expand, so have the technology tools to organize, visualize, and make sense of all that information (Cukier & Mayer-Schoenberger, 2013). The term *big data* denotes a set of data so enormous or so complex that a conventional application cannot accommodate the processing; therefore, specialized technologies must be used (Chen & Zhang, 2014; Sin & Muthu, 2015). Technology-based tools originally created in the business intelligence sector to harness the computational power of machines for data mining (Sin & Muthu, 2015) or data visualizations (Holzinger, 2013) have expanded into government, health care, and education (Chen & Zhang, 2014). These tools are further explored in the following sections along with their application in education.

Data Mining

Data mining techniques employ machine processing power to detect patterns by combing through large data sets, using algorithms, such as associations, classifications, clustering, and decision trees, to name a few (Sin & Muthu, 2015; Tair & El-Halees, 2012). Top open source tools for data mining include MongoDB, Hadoop, MapReduce, Orange, and Weka (Sin & Muthu, 2015). The growing interest in applying data mining techniques to seek patterns and make predictions about data that come from the educational domain has been demonstrated by the substantial increase in available literature on educational data mining (EDM) from 2010 until the time of this writing (Sin & Muthu, 2015; Tair & El-Halees, 2012; Williamson, 2014). The two most popular techniques used in EDM have been (a) regression analysis used in predicting values by estimating the relationship among dependent variables and (b) nearest neighbor, where a value is predicted based on records nearest to it (Sin & Muthu, 2015). Based on the results of a

case study conducted by Tair and El-Halees (2012), applying EDM techniques to a graduate student dataset containing data like GPA and demographics over a 15-year period was useful in extracting patterns and knowledge to improve graduate students' performance. Enthusiasts have seen the significant promise of EDM in improving educational systems, but critics have warned of student privacy concerns in collecting increasingly large amounts of student data without transparency about the actual purpose of doing so (Sabourin, Kosturko, FitzGerald, & McQuiggan, 2015). Another criticism of EDM involves the need for a specialized skillset to make sense of the queries compared to interactive visualization tools that enable users to visually explore data without needing to learn any programming or query languages (Morton, Balazinska, Grossman, & Mackinlay, 2014).

Data Visualization

By exploiting visual perception abilities, such as recognizing colors or distance, data visualizations can amplify cognition by helping viewers process the information more effectively (Mackinlay, 2009). For example, experimental studies have shown that information represented graphically in a chart is more persuasive than the same in a table (A. V. Pandey, Manivannan, Nov, Satterthwaite, & Bertini, 2014). Azzam, Evergreen, Germuth, and Kistler (2013) defined *data visualization* as a process that results in an image representative of raw data that is readable by viewers to support exploration, examination, and communication of that data. Large amounts of data are generated at an astonishing speed everywhere, and stakeholders from both academia and industry have improved digital tools for analyzing data of increasing volume and variety (Chen & Zhang, 2014). Several leading visualization tools have emerged from academic research, such as Tableau from Stanford University and Spotfire from the University of

Maryland; others have come from the business sector (Zhang et al., 2012). Surveying and testing the 10 most popular visual analysis tools, Zhang et al. (2012) found that the systems generally supported four features: (a) exploration that allows users to generate and verify hypotheses, (b) dashboards that support interactions like selection and filtering, (c) reporting of static summaries of data, and (d) alerts with an automatic notification when data sources reach predefined parameters.

Interactive visualization tools supplement the domain expertise of users by delivering images that leverage the power of perception to process information and generate critical questions while empowering them to explore data (Few, 2014; Morton, Bunker, Mackinlay, Morton, & Stolte, 2012; Nair, Shetty, & Shetty, 2016). That sense-making process, as shown in Figure 6 and described by Morton, Bunker, Mackinlay, Morton, and Stolte (2012), starts with a task in which a knowledge worker seeks to gain understanding. Next, the user forages for data and seeks the best visual. It is not a linear process, and at any point, questions might arise, sending the user back to look for more data or a new visual format for the information. At the core of a rich visual analysis cycle is an empowered user who both creates visualizations and changes them to search, filter, and navigate data while fluidly posing new questions (Morton et al., 2012).

Technology-based tools have substantially increased the efficiency of creating visualizations, but more importantly these tools have empowered users, who had typically been consumers of preset data reports, to lead their own inquiries and to engage in exploration and discovery that could lead to new insight (Azzam, Evergreen, Gernuth, & Kistler, 2013; Kung, 2015). Interaction techniques involve the way the user can interact with graphical models, such

as filtering data, drilling down to a subset of dimensions, zooming, and panning to see various levels of detail (Zhang et al., 2012).

Although hundreds of visualization tools are available in nearly every field, no single tool fits all functions (Nair et al., 2016). Nair, Shetty, and Shetty (2016) conducted a study that

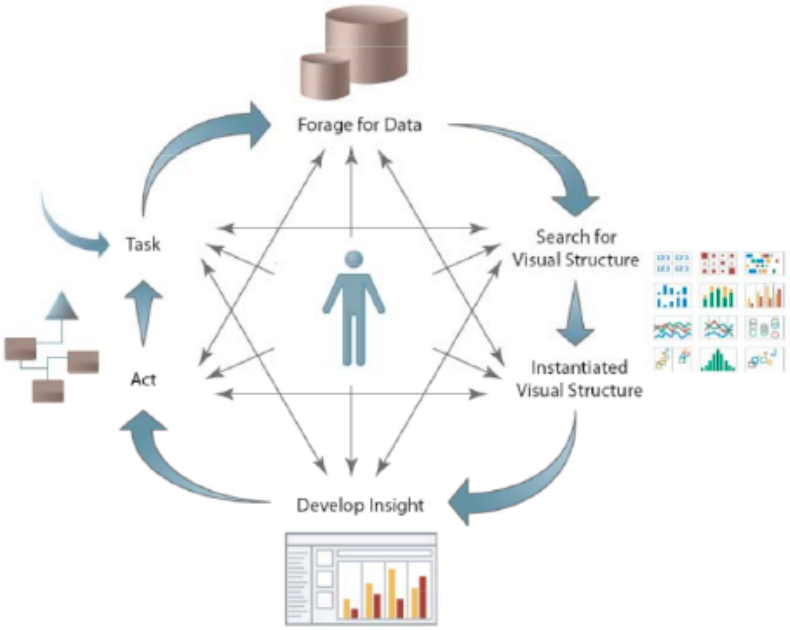

Figure 6. Cycle of visual analysis. From "Dynamic Workload Driven Data Integration in Tableau," by K. Morton, R. Bunker, J. Mackinlay, R. Morton, and C. Stolte, 2012, *ACM SIGMOD International Conference on Management of Data*, p. 1. Copyright 2012 by Morton et al. See Appendix C for permission to reprint.

resulted in the classification of the most popular visualization tools based on their proprietary rights, the requirement for knowledge of coding, and the variety of chart options. Tableau has been considered the top platform commercially available (Nair et al., 2016), featuring a drag-and-drop interface with a focus on usability without the burden of writing queries or programs, which appeals to a wide audience of end users (Morton et al., 2012; Nair et al., 2016; Wesley, Eldridge, & Terlecki, 2011). D3.js, by contrast, is an open source tool capable of highly

customized visualizations but requiring knowledge of computer programming and, therefore, appealing to a smaller audience (Nair et al., 2016). Objective evaluations are useful to businesses and school districts looking to invest in tools as well as tool designers who seek to improve those tools (Williamson, 2015).

Data Visualization in Education

The most ubiquitous type of data tool in education is the district-wide student information system (SIS), usually operated by a third-party vendor, to capture, store, and manage real-time student data on attendance, demographics, and performance (Halverson & Shapiro, 2012; Wayman, Stringfield, & Yakimowski, 2004). Generated by accountability pressures, SIS technologies were designed with administrators in mind as the end users to measure and monitor the success of the larger instructional system. The reports generated by most SIS technologies were designed to distribute preset information, which can be very valuable to school leaders who possess the knowledge and skills to explore meaningful group differences, growth over time, and program evaluation to identify root causes (Bernhardt, 2013b; Halverson & Shapiro, 2012).

In the early years of implementing new data platforms, principals identified several barriers to beneficial use, including excessive raw data, inadequate technology, lack of coordination between data sources, and lack of timely data (Reeves & Burt, 2006). Technology has improved to the point where many principals have access to real-time data dashboards that bring together multiple measures to help educators quickly diagnose what is and is not working for students (Darling-Hammond et al., 2016). By bringing together a variety of data sources with multilevel aggregation and disaggregation, information technology has increased educators' understanding of factors affecting student performance and enabled districts to identify schools

in need of additional support. Schwendimann el al. (2016) offered a definition of a *learning dashboard* as a single display that aggregates multiple visualizations of different indicators about learners, learning processes, and learning contexts. The purpose of most dashboards was self-monitoring, followed by monitoring of others and administrative monitoring (Schwendimann et al., 2016).

Interactive data dashboards can empower educators to initiate their own queries in order to explore the intersection of multiple types of data for trends and insight. Some examples of commercialized data visualization platforms that have recently expanded from the business intelligence community into the education community include Tableau and IBM's Cognos (Wong, 2016) in addition to tools specially designed for education like Pearson's Learning Curve Data Bank and Schoolnet (Blanc & Christman, 2005; Williamson, 2014). Because most student information systems generate basic reports on current-year data points, school personnel often think they already have access to the data they need without realizing how useful it is to have dashboards that connect silos of data, compare historical data trends, and enable disaggregation of data (Lachat & Smith, 2005; Wong, 2016). Educators from the Spokane Public School District have described the usefulness of their data dashboard, shown in Figure 7, in integrating multiple data sources to identify multiple risk factors and improve graduation rates from 76.6% to 84.5% over three years (Tableau staff, n.d.; *Seattle Times* staff, 2012; Wong, 2016).

One relevant case study on data use and systemic improvement involved the work of the Chicago Public Schools to reduce the high school dropout rate using at-risk student identification metrics devised by the 2007 University of Chicago Consortium on School Research (Roderick, Kelley-Kemple, Johnson, & Beechum, 2014). Chicago Public Schools generated data reports for

teachers and administrators on the number of absences and course performance to identify ninth-grade students with more than one failing grade at the semester mark, who may be at risk of dropping out. The availability of real-time data reports was a key turning point for positive

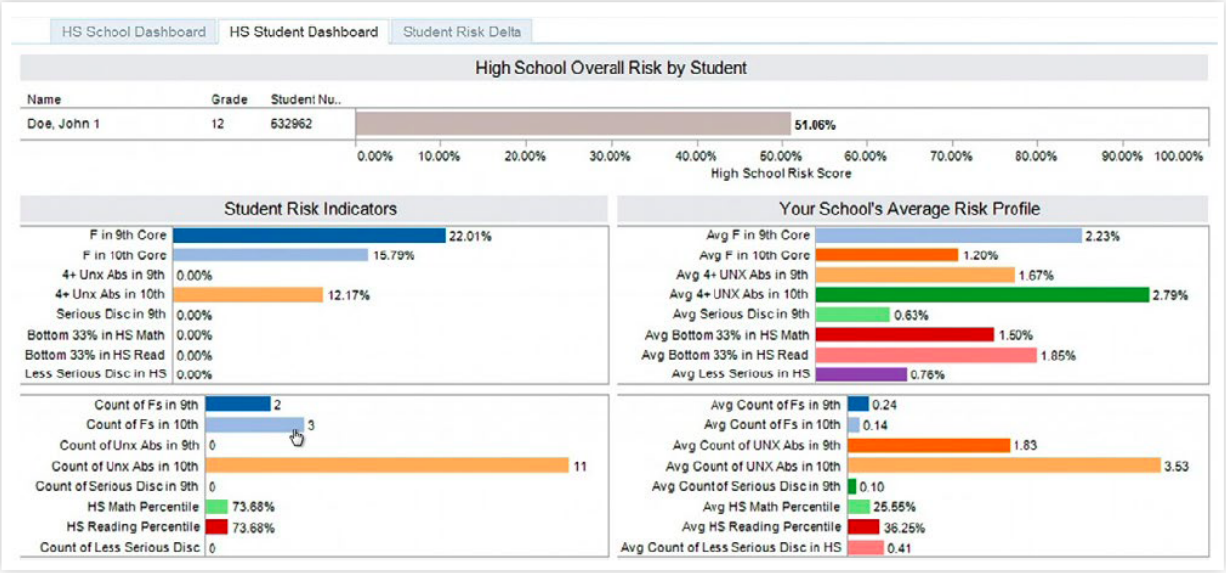

Figure 7. Spokane Washington School District dashboard to track multiple risk factors. From "Early Indicators: Using Data to Keep High-Risk Students in the Classroom," *Tableau,* p.6. Copyright n.d. by Tableau. Reprinted with permission and thanks to Tableau and Steven Gering, Chief Academic Officer, Spokane School District. See Appendix D for permission to reprint.

changes in outcomes. "The effort appears to have paid substantial dividends: between 2007 and 2013, the CPS on-track rate rose 25 percentage points, from 57 to 82 percent" (Roderick et al., 2014, p. 4), and those improvements were sustained through Grades 10 and 11, and ultimately led to improved high school graduation rates. School-level administrators stated that the data reports have changed the dynamic of conversations with teachers to drive instructional improvement and coordinated support (Roderick et al., 2014).

Challenges with Data Tools in Education

The rise of data collection in education by state agencies, private companies, and other organizations has created a range of datasets consumed for different purposes. Challenges still exist in using computer systems to support data analysis in education, including disparate data collection (Wayman et al., 2010), lack of security (Horn, 2014), and unclear ownership of student data (Sabourin et al., 2015). Despite improved interoperability standards (Jakimoski, 2016), several researchers have found that an impediment to data use continues to be the lack of integration and data sharing among the various systems in use. This lack of integration has actually affected the way educators conducted their work, increased their levels of frustration, and wasted many hours of administrators' time each year (Wayman et al., 2010). Comprehensive studies of school districts in the US (Lachat & Smith, 2005) as well as abroad (Schildkamp & Kuiper, 2010) continue to draw attention to issues of data quality and the importance of timely data in fully integrated databases.

Data systems can limit users by restricting access or views based on what the designers and system managers want them to see (Selwyn et al., 2015). The highly mediated relationship has led critics to suggest that the data themselves do not represent neutral facts but instead the political choices of the policy makers and tool designers (Selwyn et al., 2015). Focus groups with educators have revealed the desire for greater customization with their data platforms (Wayman & Stringfield, 2006). Advancements in both hardware and software have resulted in more powerful, efficient, and usable tools, which have increased the need for the ongoing evaluation of these tools. Users seldom know exactly what will be most useful until they are in the midst of the work, and tool developers can only make assumptions without end-user data; user experience

must be studied in order to produce continuous improvements in the tools, especially because tools have continued to evolve (Brhel, Meth, Maedche, & Werder, 2015; Conaway et al., 2015).

User Experience

Human–computer interaction is a growing field of research involving many aspects of the user experience (UX), including the extent to which technology is both useful and usable. Software developers employing a user-centered design approach have become interested in user-centered evaluations and an iterative refinement of the product (Nielsen, 1993) that can lead to such benefits as higher adoption, increased ease of use, and a pleasant user experience (Abras, Maloney-Krichmar, & Preece, 2004; Brhel et al., 2015). Although the majority of user-experience research was collected during the early phases of software development in order to shape design, studies have shown a need to systematically investigate the continuous end-user experience (Brhel et al., 2015). Ongoing evaluation is especially important, given the potential mismatch between designers' intentions and users' actual experience (Blythe, Reid, Wright, & Geelhoed, 2006). This section of the literature review includes an exploration of the history of UX research, the application of user studies with data visualization software, user studies in the field of education, and the need for further studies of end users.

History of the Term *User Experience*

In *The Psychology of Everyday Things*, a seminal work on user-centered design, Norman (1988) argued that the human mind is exquisitely tailored to make sense of the world, so well-designed objects are easy to interpret and understand, but poorly designed objects are frustrating. Nielsen (1993) defined five usability goals in his seminal user studies: learnability, efficiency, memorability, error-forgiveness, and satisfaction. In his case studies of four emerging

computerized systems in the field of finance, Nielsen (1993) transformed subjective ratings on his usability criteria into a ratio scale in order to collect comparable data through observations of users performing tasks, documenting the number of errors and having users respond to a satisfaction questionnaire. Nielsen (1993) concluded that although he used 10 different test subjects in five iterations of the software, the data supported substantially improved usability with fewer subjects and just three initial iterations of the software. Subsequent user studies employing think-alouds confirmed that a small sample size of five subjects was ideal before seeing diminishing returns (Nielsen, 1994).

Nielsen's work has been criticized by some for failing to balance other considerations of UX, a field that came into focus in 1996 as a way to separate the experiential aspects of technology use from the traditional task-oriented usability metrics (Hassenzahl & Tractinsky, 2006). Used primarily in the field of human–computer interaction (HCI) to measure such factors as beauty, elements of surprise, intimacy, and other elicited emotions, UX has the ability to capture the noninstrumental values desired and valued in products (Tractinsky, Katz, & Ikar, 2000). After conducting experimental sessions with users performing tasks on various automated teller machine layouts, user perceptions of the beauty of a system showed a strong correlation with perceived usability (Tractinsky et al., 2000). As a result of UX research highlighting the importance of the aesthetic experience, interactive products are now not only more useful but also more fashionable and fascinating objects that people want to use (Hassenzahl & Tractinsky, 2006; M. Scholl, 2015). UX is shaped by previous experiences and the expectations of the user (Kankainen, 2002). Critics of UX research have challenged it as vague and elusive, citing UX

researchers' frequent difficulty in establishing a common view of what constitutes a good UX because the metrics depend on the goal of the product (Hassenzahl & Tractinsky, 2006).

User-Experience Research on Data Visualization Tools

In terms of data visualization platforms, the purpose of using that visualization is to gain insight (Boy, Detienne, & Fekete, 2015; Dove & Jones, 2012; Rodden, Hutchinson, & Fu, 2010). Dove and Jones (2012) drew upon the literature of cognitive psychology and the InfoVis community to argue that insight is both experienced and the product of that experience. A relatively small body of literature is concerned with measuring the experience of using data visualization to gain insight, but in one such study Boy, Detienne, and Fekete (2015) conducted three web-based field experiments on a popular news website to determine the likelihood that enhancements to the data visualizations would motivate viewers to explore them further to gain additional insight beyond what was provided by the journalist. In contrast to their hypothesis, they found that their effort to augment the visualizations with introductory stories did not increase user engagement or additional meaningful clicks to further query the data. They found other benefits, including a high number of webpage visits, and suggested further research was needed to define the concept of engagement in the context of data visualizations and to surpass narrowly defined parameters.

Many user researchers who have intentionally forgone quantitative measures in favor of a qualitative approach with open-ended research questions often do so because they desire a deep understanding of the UX (Huang, Tory, & Bartram, 2016). The purpose of Huang, Tory, and Bartram's (2016) eight-week field study of 21 Fitbit users was to compare a visualization group with integrated fitness feedback data in their personal calendars to the control group with a

standard Fitbit feedback tool in order to explore user reactions. Through weekly surveys and interviews, the reactions of the visualization group were positive, and the promising results served as a starting point for designers looking to blend various contextualized data sources (Huang et al., 2016). The vast majority of user studies have provided designers with useful information to improve tools, but some user studies were intended to benefit the users themselves, such as the survey and evaluation conducted by Zhang et al. (2012) of the top 15 commercial providers of visualization analysis systems. All software was installed and tested by the research team with a common reference dataset, such as health data, to compare the functionality of the systems while answering a common query (Zhang et al., 2012). The resulting evaluation highlighted systems strengths like Tableau and JMP, which offered supportive built-in wizards while indicating that other systems like Spotfire and QlikView required additional steps and challenges for the user with the tradeoff for more customization (Zhang et al., 2012). The generalizability of this type of research to the field of education is problematic because the context and purpose of use are quite different and tools that might be considered user friendly to one role group might not be considered so for another (Wayman & Stringfield, 2006; Wayman et al., 2010).

User-Experience Research in Education

When conducting user studies in the field of education, considering the range of users is beneficial; these include primary users, such as students, teachers, or principals; secondary users, such as those who manage the systems; and tertiary users, such as leaders who benefit from artifacts or make decisions about their purchase (Abras et al., 2004). User studies in education have primarily focused on understanding the needs of teachers and students in specific usage

contexts in order to inform product enhancements and user support (Freitas, Costa, & Neri deSouza, 2016; H. J. Scholl, Eisenberg, Dirks, & Carlson, 2011; M. Scholl, 2015). Numerous studies have been conducted to measure adults' use of data (Huguet et al., 2014), but fewer studies have been conducted to measure the relationship between that data use and student achievement outcomes. Wayman, Shaw, and Cho (2017), who sought to address that gap by linking teachers' data system use logs to student achievement on state tests, found only one significant relationship in elementary reading, where the data use was associated with reading gains, but no significant relationship in math. The conclusions of Wayman et al. (2017) added to the growing body of research emphasizing that viewing data is not enough; a transformation process must take place in order to turn the information into usable knowledge (Wayman et al., 2004). The following quotation exemplifies the sentiment that data analysis is a deeply human process:

> Much of the work of data use would be difficult, if not impossible, without data systems. The conventional wisdom about these systems, however, has been technologically deterministic: it is commonly assumed that data systems are "tools" with predetermined "effects" on how educators go about their jobs. In this view, bringing about changes to practice becomes a matter of ensuring access to the "right system" with the "right data." Focusing on such technical issues, however, obscures the importance of the "people problems" around data systems. (Cho &Wayman, 2014, p. 4)

To understand the people problems and UX in a systematic way, researchers have anchored their findings in a framework.

Multiple UX frameworks have been used in the field of education in the absence of a commonly adopted framework. In an evaluative study conducted with students using Moodle course rooms, the Taylor, Eisenberg, Dirks, and School framework, called TEDS, was used with 40 UX criteria to identify the users' wants and needs along with the specific scenarios of use (M. Scholl, 2015). The study illuminated the need for simpler and more organized information on Moodle that was capable of being easily located by the specific user groups. The goal of increasing perceived ease of use and usefulness has been echoed in other frameworks, such as the technology acceptance model 3 (TAM3) (Venkatesh & Bala, 2008). TAM3 has been used as an analytical lens in the field of educational technology, for example, to explore how school principals and IT managers perceived the usefulness and ease of use of their schools' information and communication technology (ICT) systems (Babaheidari & Svensson, 2014). The patterns emerging from that user study revealed a lack of coordinated ICT investment strategy and the need for holistic managerial thinking (Babaheidari & Svensson, 2014). With a growing number of emergent digital tools in the field of education, looking at the UX with particular products became necessary as articulated below:

> Apparently these two concepts (usability and user experience) seem to be antagonistic, as one is characterised by its rationality and the other by its apparent emotionality. It is in this juncture that fits the challenge of developing "interactive educational applications," these applications being characterised by its good usability and by simultaneously providing a pleasant and efficient experience to users. However, the focus on developing interactive educational resources is constantly centered on satisfaction and experience

> that this provides the user, hence it is important to be knowledgeable of the user experience in interaction with a particular application. (Freitas et al., 2016, p. 165)

Wayman, Stringfield, and Yakimowski (2004) were among the first to systematically describe, classify, and evaluate emerging data analysis tools for educators. Their criteria included user friendliness, user features, information access, creating and sustaining quality data, and additional features. After reviewing 13 major platforms, they concluded that no single tool met all the criteria for important features; instead tools served a variety of purposes, and researching the practical use teachers and principals make of these tools was important (Wayman et al., 2004). The crucial perspective of the educators as end users in a practical setting was admittedly lacking in their study. Also interested in the usefulness of multiple data applications, Mandinach, Honey, and Light (2006) confirmed that the characteristics of the tool itself impact how the data are examined, the types of questions asked, and by whom. Datnow and Park (2014) asserted that fully determining whether data use tools designed to support educators are effective is impossible without knowing how they are used in schools.

To date, little research has been conducted to evaluate the impact of interactive data visualizations tools to promote new understanding among educators (Kia, Pardos, & Hatala, 2016). One criticism of existing research is that it has focused on preset visualizations (Duval, 2011), demonstrating indicators like demographics and performance built for specific agendas that may or may not match the issues users want to explore (Kia et al., 2016). After conducting a qualitative user study with five participants to examine the usability of a data dashboard, Kia, Pardos, and Hatala (2016) found that the application of interactive filters facilitated exploring large data sets in an intuitive fashion and provided information that enabled conversations to take

place. One of the great promises of analytics in education is the ability of digital systems to generate timely and meaningful data that inform future practice, but more research is needed to determine whether the analytic tools truly serve in that supportive role (Corrin et al., 2015).

This literature review has provided a summary of user-experience research, technology developments that support data analysis, and the context of educator data use. The next section situates data analysis activity in a broader theoretical framework.

Theoretical Framework

The field of human–computer interaction (HCI) along with its subareas like UX have no shared theoretical foundation, but activity theory has been widely used in HCI since the mid 1990s (Clemmensen et al., 2016). Activity theory aims to understand human beings as well as the entities they constitute through an analysis of the genesis, structure, and process of their daily activities (Kaptelinin & Nardi, 2006). Activity refers to purposeful interaction of the subject and object in which mutual transformation between the two takes place. The unity of consciousness and activity is a foundational idea underlying activity theory. On the surface other HCI approaches such as UX studies may appear to focus on the same unit of analysis as activity theory, that is, on interaction between users and interactive systems; however, activity theory moves beyond individual tasks to accommodate the broader meaning of the activity for the subject. In activity theory emphasis is placed on the importance of studying the real-life use of technology as a part of unfolding human interaction with the world, where activities are carried out to accomplish tasks regardless of the technology itself, such as the activity of sending a message (Kaptelinin & Nardi, 2006).

One fundamental underpinning of activity theory, also referred to as cultural–historical activity theory (CHAT), is the idea that the human mind is social by nature; thus, every activity is situated in a larger social context. Its early roots derived from Soviet cultural–historical psychology, including Vygotsky's social nature of the human mind and Rubinshtein's mediating inseparability of the mind and activity (Clemmensen et al., 2016). Leontiev's first generation of activity theory, shown in Figure 8, was based on the idea that the subject, the human, is shaped by the tools used, either physical or abstract (Nardi, 1996). The object can be a material product or an intangible like an idea or plan. The transformation process of turning that object into an outcome is what motivates the existence of an activity (Kuutti, 1996). A tool can be both

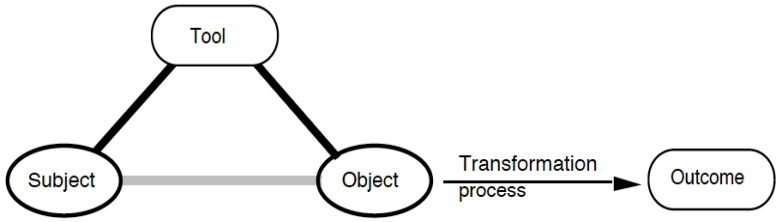

Figure 8. First-generation activity theory. From "Activity Theory as a Potential Framework for Human–Computer Interaction Research" (p. 24), by K. Kuutti in *Context and Consciousness: Activity Theory and Human Computer Interaction*, 1996. Cambridge, MA: Massachusetts Institute of Technology Press. Copyright 1996 by K. Kutti. See Appendix E for permission to reprint.

empowering and limiting at the same time by restricting the interaction based on the available features of that tool (Kuutti, 1996).

Because of its use by researchers in education, organizational learning, and psychology, activity theory has spread geographically and across disciplines (Bligh & Flood, 2015; Clemmensen et al., 2016; Nardi, 1996). Yrjö Engeström advanced the theory by considering the

component of community along with the additional mediated relationships formed to create the second-generation activity theory model shown in Figure 9 (Kuutti, 1996). The subject–community relationship is mediated by rules; the community–object relationship is mediated by division of labor.

Analyzing the practice of a human is difficult without attention to the rules and resources from the contextual activity system that enables and constrains interactions (Spillane, 2012). The emphasis on social factors helps to explain why the principle of tool mediation plays a central role in activity theory. As tools shape the way human beings interact with their external reality,

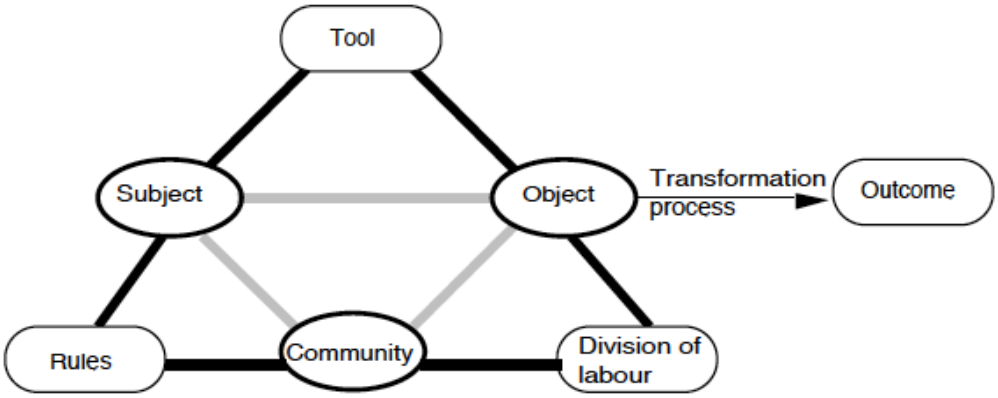

Figure 9. Second-generation of activity theory. From "Activity Theory as a Potential Framework for Human–Computer Interaction Research" (p. 24), by K. Kuutti in *Context and Consciousness: Activity Theory and Human–Computer Interaction*, 1996. Cambridge, MA: Massachusetts Institute of Technology Press. Copyright 1996 by K. Kuutti. See Appendix E for permission to reprint.

the shaping of external activities eventually results in the shaping of internal ones as well in a process of internalization–externalization (Kaptelinin & Nardi, 2006). Tools reflect the experience of the creators who were motivated to meet the needs that shaped the structural properties of the tools and the knowledge of the way the tool should be used; this historical

evidence of development influences users (Kaptelinin & Nardi, 2006). Tools serve as fundamental mediators of human actions that relate human beings in the present to the cultural and historical development of those tools (Cole & Engeström, 1993; Kaptelinin & Nardi, 2006).

Clemmensen, Kaptelinin, and Nardi (2016) conducted a metasynthesis of the use of activity theory in 109 HCI papers since 2000 and found that the activity system model was often used in studies embedded in work places. In 30 of the 109 papers reviewed by Clemmensen et al., activity theory was used to conceptualize various kinds of computer-supported work with a focus on interfaces and development of IT systems. Concerned with everyday practices, activity theory can describe context and use situations, tool mediation and the role of technology in work practices, and the object or objectives of the task to be supported (Clemmensen et al., 2016; Nardi, 1996). Activity theory has continued to evolve, and a third and fourth generation include multiple perspectives and intersecting activities of individuals and groups (Allen et al., 2011; Engeström, 2001). The use of activity theory to describe information-seeking behavior has increased since research in this area shifted towards qualitative analysis (Allen et al., 2011).

Activity Theory in Educational Context

Activity theory has been commonly used in educational investigations as a conceptual lens for interpretive data analysis (Gedera & Williams, 2016). The well-known triangular model of an activity system (Engeström, 2001) can be used to create a visual of the context and related components in an educational process under investigation. For example, it has been used to conceptualize the activity of students completing assignments using digital and nondigital tools, such as textbooks and the Internet (Allen et al., 2011), to explore the relationships with those mediating tools. In one particularly relevant study of a school reform network in Hawai‘i,

Suthers, Yukawa, and Harada (2007) used third-generation activity theory to understand the strengths and challenges with respect to the role of technology in mediating professional development between three related activity systems. The object of the reform was to change the practices of teachers to ultimately create an outcome of student achievement gains. The findings illuminated tensions that arose in teachers' activity systems, including limited technology, lack of technical knowledge, inexperience with collaborative technologies, and insufficient resources and time for professional development (Suthers et al., 2007). Activity theory has proven to be a useful structural model in which contradictions or tensions of educational processes can be identified and relations between the characteristics of the system can be determined (Cole & Engeström, 1993; Gedera & Williams, 2016).

Activity Theory Applied to School Leader Data Analysis

Building upon the work of other researchers in the field of education and HCI (Allen et al., 2011), activity theory can be used to frame and describe the mediated relationships among (a) a subject, the school leader; (b) the object, data; and (c) the school community as illustrated in Figure 11. The objective of engaging in such activity is to gain insight, which has been described as a discovery resulting in new understanding (Dove & Jones, 2012). The ultimate outcome of analyzing data is the transformation process in which that insight turns into a decision that will be implemented in order to have an impact (Mandinach et al., 2006). The outcome is what motivates the subject's activity (Kuutti, 1996).

Principals play a central role in data-informed decisions at schools (Huguet et al., 2014; Jimerson, 2014; Wayman et al., 2012). Tools that mediate the relationship between the principal and data include the data systems and visualizations tools that might both empower them or limit

them. In this mediated relationship the subject can be impacted by the experience: As users gain insights and information using data visualization tools, they may generate new questions, a need for new data sources, and new uses for the data (Morton et al., 2012).

The community component highlights the shared context of work activity (Allen et al., 2011). The local school community which consists of the faculty (Wayman et al., 2012) is nested within the broader school district community (Dougherty, 2015). Sometimes district supports are helpful in division of labor, but other times school leaders receive only minimal support (Bottoms & O'Neill, 2001; Leithwood, 2013). Major mediating factors between the school

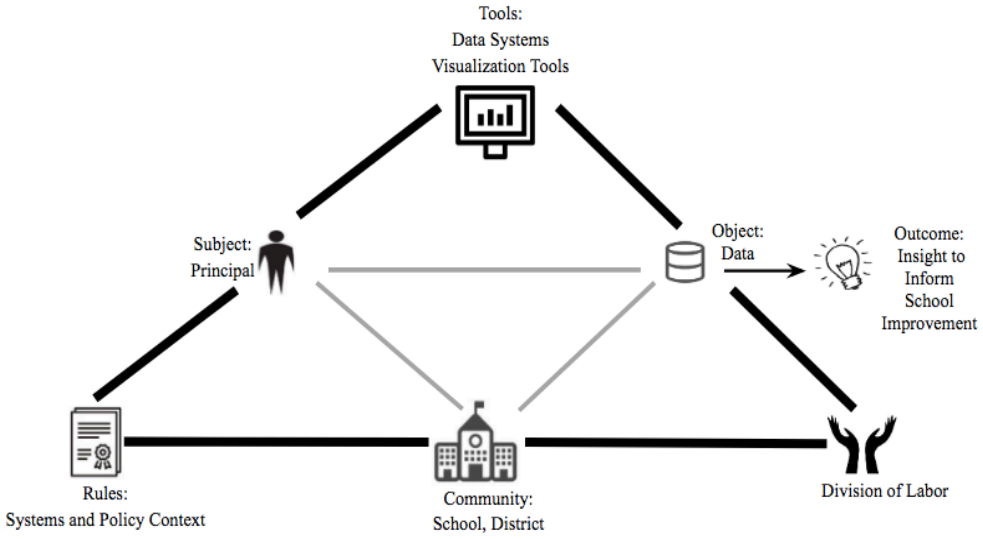

Figure 10. Principals' data use as an activity system.

leader and their community include the systems and policies that substantially influence all aspects of data use in education (Briggs et al., 2013; Datnow & Park, 2014). The components of this framework were selected in alignment with the literature reviewed around motivation for data analysis, factors influencing data use, and the intended outcome of data visualization tools.

Summary

With regard to school reform since the 1990s, much has changed in terms of policies, technology, and expectations related to the unprecedented amounts of data now available to educators. Decision-makers at the school, district, and policy levels are expected to analyze data and formulate conclusions to inform everything from everyday decisions to long-range strategies. The complexity of analyzing data, especially large sets of them has been largely aided by technology-based tools, which have become quite sophisticated in recent years (Mandinach et al., 2006; Verbert, Duval, Klerkx, Govaerts, & Santos, 2013). Even at a time when educational systems have been inundated with graphical data, including diagrams, charts, tables, infographics, and other forms of representations, the effectiveness of these tools in the context of education and improving systemic change remains an emerging area of study that warrants further research (Williamson, 2014). The lack of research on these emerging tools has left the educational community with powerful analytic tools but a shallow understanding of data use (Schildkamp & Kuiper, 2010). Research to understand UX with data visualization tools could inform districts looking to invest in tools or to support users to make the most of them (Coburn & Turner, 2011). This review of related literature covered the history of data-informed decision-making in education, the central role of school leaders, the role of technology-based tools, and the use of activity theory to describe how the variables are related. Chapter 3 contains a review of the methodology used in this study.

CHAPTER 3. METHODOLOGY

The purpose of this mixed methods study was to understand the experience of principals as they used data analytic tools in a K–12 system by posing and exploring the following questions:

RQ1. What types of data and data analytic tools do principals use?

RQ2. How do principals use data analytic tools?

RQ3. What factors influence principals' use of data analytic tools?

RQ4. How do principals describe the impact of data analytic tools on their work?

This chapter includes the methodology, the research design, conceptual framework, participants and context, role of the researcher, instrumentation and procedures, and data collection, and data analysis.

Research Design

This study was grounded in a mixed methods approach, in which the philosophical positions, inferences, and interpretations of data emanating from both qualitative and quantitative research traditions were commingled (Tashakkori & Teddlie, 1998). Two distinct phases of data collection and analysis were incorporated in an explanatory sequential research design (Tashakkori & Teddlie, 1998), chosen over other designs so that trends and follow-up questions could first emerge from the quantitative data with the opportunity to explore the reasons behind those trends in the qualitative data collection (Creswell & Plano Clark, 2011). Phase 1 involved quantitative data collection in the form of an online survey; Phase 2 involved qualitative data collection in the form of document analysis, think-alouds, observations, and semistructured

interviews. The following sections detail the purpose of each research tradition and how it has informed the process of research in this study.

Quantitative Research

In quantitative studies, researchers collect quantifiable data in an unbiased, objective manner (Creswell, 2008b). Stemming from the physical sciences, early educational research was used to identify patterns in measures of abilities, scores, and surveys in the late 19th century (Creswell, 2008b). Approaches to quantitative data in educational research have evolved over time to include experimental studies and complicated designs with multiple groups and multiple tests (Creswell, 2008b). Quantitative methodology was appropriate in this study because some of the research questions were oriented toward description and explanation that can be collected with quantitative tools. These questions included the following: What types of data and data analytic tools do principal use? and What factors influence principals' use of data analytic tools? A survey tool was used for data collection because it provided an opportunity to gather information from a large number of individuals and measure the factors aligned with the theoretical framework.

Qualitative Research

Qualitative researchers are interested in understanding human behaviors and the reasons behind them: the why or how, not just the what, where, and when (Ary et al., 2013). An underlying assumption in the field of qualitative research is that human behavior is always social and bound to the context in which it occurs; therefore, its goal is to understand the meaning constructed by the participants as they perceived it (Creswell, 2008b). The personal nature of qualitative research is such that the inherent subjectivity and biases of both participants and

researchers are acknowledged (Ary et al., 2013). A qualitative approach was appropriate for Phase 2 of this study in order to deepen understanding of the participants' experiences. Qualitative data collection tends to consist of emerging questions, data in the form of words, and information from a smaller number of individuals (Creswell, 2008b). The goal—to "portray the complex pattern of what is being studied in sufficient depth and detail so that someone who has not experienced it can understand it" (Ary et al., 2013, p. 448)—aligned with the purpose of this study. The interpretations and analysis of emerging themes from the qualitative data collected enhanced understanding of principals' experiences using data analysis tools and the factors affecting their use. The following research questions were appropriately explored with qualitative methods: How do principals use data analytic tools? and How do principals describe the impact of data analytic tools on their work? Qualitative methods may also be used to deepen understanding of the tools school leaders use and the factors that influence their choices.

Mixed Methods Research

With roots in the social and behavioral sciences, mixed methods research designs can be used in a variety of disciplines to more fully answer research questions than sole reliance on either a quantitative or qualitative approach can accomplish (Tashakkori & Teddlie, 1998). An explanatory sequential research design was used in this study to allow for data collection and analysis to take place in two distinct interactive phases (Creswell & Plano Clark, 2007). The quantitative data were collected and analyzed first, followed by in-depth qualitative data collection and analysis to enhance answers to the research questions.

In Phase 1, a 15-minute online survey was sent to all public school principals in the Hawai‘i Department of Education in order to collect quantitative data on population trends.

Descriptive statistics provided initial answers to two of the research questions and helped the researcher to refine the questions for Phase 2. The quantitative results were also used to identify a purposive sample of six principals for participation in the qualitative phase. The qualitative data collection in Phase 2 was strengthened by using a variety of techniques: interviews, observations, field notes, and document review (Ary et al., 2013). The researcher opened the second phase of data collection with a document analysis of the publicly available academic plans for the schools represented by the six principals continuing to Phase 2. The purpose of reviewing the academic plans was to understand the school improvement goals and the indicators of progress the school leaders analyzed as a part of the school improvement process. The researcher then scheduled 30-minute think-aloud and observation sessions in which the principals interacted with tools of their choice, followed by a 30-minute semistructured interview. The qualitative data collection and analysis provided an opportunity for the researcher (a) to understand the principals' experiences in light of the trends that emerged from the quantitative survey results and (b) to answer the "how" research questions. Member checks were conducted to ensure the accuracy of the data collected. Data were coded for themes, and triangulation of multiple data points supported interpretation by the researcher (Ary et al., 2013).

Conceptual Framework

Activity theory served as the foundation for shaping the research questions and research design. The first two research questions were designed to learn about the mediating role played by tools in the context of principals' data use:

RQ1: What type of data and data analytic tools do principals use?

RQ2: How do principals use data analytic tools?

The third research question was designed to understand the factors in the subject and community that may influence data use:

RQ3: What factors influence principals' use of data analytic tools?

Finally, the fourth research question was designed to ascertain the ultimate outcome of data analysis by asking the following:

RQ4: How do principals describe the impact of data analytic tools on their work?

The research questions have been visually aligned with the conceptual framework designed by the researcher in Figure 11.

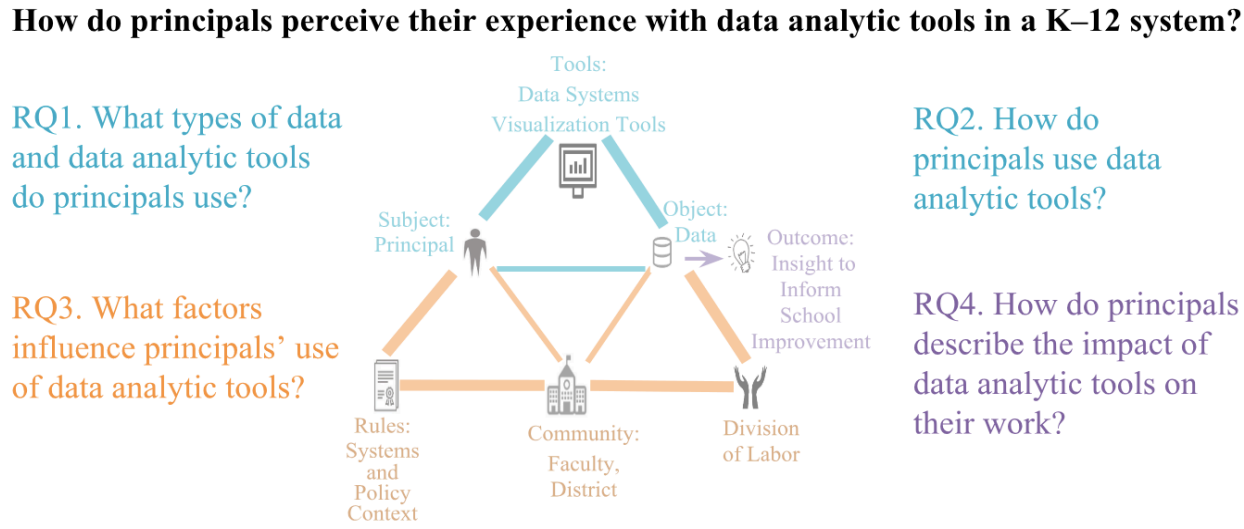

Figure 11. Alignment of research questions with framework.

Participants

School principals were chosen as the focus population because of their key role in shaping data use at schools (Schildkamp & Kuiper, 2010). At the time of this writing, a total of 256 public school principals were employed by the Hawai'i Department of Education in a single statewide K–12 school system. The sample sizes for each phase of this research differed based on saturation of data and the methodology used in each phase (Merriam & Tisdell, 2015).

Phase One Participants

Because quantitative data collection and analysis were intended to allow the researcher to describe broad trends in the population, all public school principals in the district under study were invited to participate in the initial online survey. The invitation followed the recommendation of Wayman, Wilkerson, Cho, Mandinach, and Supovitz (2016) to survey as many educators as possible to gather information about data use throughout a district. Approval was sought from the university's Institutional Review Board as well as the school district in the study in order to ensure that the procedures and materials provided participants with appropriate protections (Creswell, 2008b). Once approvals were secured, e-mail addresses of the principals were obtained through the publicly available district directory hosted on the school district's website. An email invitation was sent to all principals explaining the purpose of the study, the potential benefits, the confidentiality of responses, and the voluntary nature of their participation in the survey. The email contained the informed consent document, the Hawai'i Department of Education approval, and a link for the participants to indicate their consent to participate in the online survey. The final question in the survey asked principals whether they would be willing to participate in a follow-up interview and observation. Once the survey closed, the results were reviewed to identify those willing to participate in the second phase.

Phase Two Participants

A purposive sample of six principals were invited to participate in the qualitative data collection in Phase 2. In deciding the appropriate sample size, the researcher considered the recommendations for saturation of data for both the think-aloud and interview methodologies. Studies have shown that four to five participants are sufficient in think-aloud studies and that the

value of the additional information beyond six subjects falls off exponentially (Nielsen, 1994). The sample size of an interview methodology that results in a saturation of data ranges from six participants with 94% of codes identified to 12 interviews with 97% of codes identified (Guest, Bunce, & Johnson, 2006). Because both think-aloud and semistructured interview methodologies were used, a sample size of six was deemed suitable for both methods.

Selecting the six principals to participate in Phase 2 of research began with the list of participants who responded to the survey in Phase 1 and indicated a willingness to engage in a follow-up observation and interview. Volunteer participants who worked directly with the researcher in her role as an educational officer were excluded from Phase 2 to reduce bias. Creswell (2008b) recommended selecting purposive samples of participants that are "information rich." The six participants in Phase 2 showed variation in their User Characteristics Scale from the survey, their representation of elementary and secondary school levels, generations, and geographic location. The volunteers for the Phase 2 qualitative data collection were contacted through their publicly available email addresses to confirm their interest and willingness to participate in Phase 2 of the research and were sent a second consent form for review, which they signed and submitted at the time of the think-aloud, observation, and interview. After two female volunteers were nonresponsive to the email correspondence, the population for Phase 2 consisted of a larger representation of males. Although the gender imbalance was not ideal, no evidence indicated that gender was a major factor influencing users in this activity system. While analyzing the survey results from Phase 1, several *t*-tests were run to determine whether a significant difference existed in the means of males or females on the various scales; but none of the *t*-tests resulted in a significant statistical difference.

Instrumentation and Procedures

The instrumentation and procedures for each phase of the research were informed by the literature review, the research questions, and recommendations for mixed methods research. The ultimate goal was to understand the principals' experiences using data analytic tools in a K–12 setting and the factors affecting their use. The key components conceptualized using the activity theory framework were the subject (the principal), tools (data analytic tools), community (faculty and district), and the object (data use for school improvement).

Phase One Instrumentation

A survey about data use was selected in order to obtain a general description of what types of data and tools principals use (RQ1) and what factors influenced their use (RQ3). The survey instrument consisted of subscales from two primary sources: (a) Factors Promoting and Hindering Data-Based Decision Making in Schools Survey (Schildkamp et al., 2016), and (b) Teacher Data Use Survey: Administrator Version (Wayman et al., 2016). The researcher followed suggestions outlined by Creswell (2008b) for selecting good instruments by emailing the survey authors to obtain the most recent version of the survey, looking for information about the reliability and validity of scores from past use, and considering instruments that contained accepted scales of measurement.

To answer the first research question and obtain descriptive data about the data tools principals use, the researcher included three questions from the Teacher Data Use Survey: Administrator Version (Wayman et al., 2016). Permission was granted to use the survey items as well as the survey protocols (see Appendix F). First, principals were asked how frequently they used various types of data. The types of data listed were inspired by those appearing on the

Principals' Use of Data Systems to Enhance Student Achievement in Mathematics Survey (Williams, 2011) as well as tools made available by the Hawai‘i Department of Education. If respondents marked Other, they had the opportunity to add to that list. Second, principals were asked how frequently they used the numerous types of data tools available to them in the Hawai‘i Department of Education. Finally, respondents were asked to share their perceptions of the computer system characteristics based on the questions associated with that subscale from the Teacher Data Use Survey: Administrator Version, a scale that had a Cronbach's alpha of 0.85 or higher in pilot studies (Wayman et al., 2016).

During Phase 1, quantitative data were collected to explore possible factors that influenced principals' data use (RQ3) with subscales from the Factors Promoting and Hindering Data-Based Decision-Making in Schools Survey (Schildkamp et al., 2016). See Appendix A for permission granted from the author to use the survey instrument. Originally designed to study the components of the data use framework outlined by Schildkamp et al. (2012), this survey had seven subscales: (a) data use for accountability with three items and a Cronbach's alpha of 0.75; (b) data use for school development with nine items and a Cronbach's alpha of 0.87; (c) data use for instruction with 11 items and a Cronbach's alpha of 0.91; (d) collaboration with three items and a Cronbach's alpha of 0.74; (e) school organization characteristics with 16 items on vision and norms, leadership, and support and a Cronbach's alpha of 0.92, (f) user characteristics with eight items for knowledge and skills, dispositions to use data and a Cronbach's alpha of 0.80; and (g) data characteristics with 11 items for accessibility of timely data, usability, and quality and a Cronbach's alpha of 0.85. Each question was designed to elicit responses in the form of a 4-point scale: 1 (*strongly disagree*), 2 (*disagree*), 3 (*agree*), and 4 (*strongly agree*). When the

authors conducted confirmative factor analysis and reliability analysis, they found a four-factor structure almost consistent with their data use framework: school organizational characteristics, data characteristics, user characteristics, and collaboration (Schildkamp et al., 2016). The subscales chosen for their alignment with the activity theory framework used in this study are as follows: (a) data use for school development, (b) school organization characteristics (vision and norms, leadership, and support), (c) user characteristics (knowledge and skills, dispositions to use data), and (d) data characteristics (accessibility of timely data, usability, and quality). A copy of the survey is located in Appendix G.

Surveys have been a useful data collection tool in other studies to describe educators' data use (Jimerson, 2016; Schildkamp et al., 2016; Wayman et al., 2017), but in the literature reviewed, the purpose of most surveys was to describe teacher data use. As a result, the researcher had to modify the terminology in the survey instrument so that a principal could answer the questions in first person. As shown in Figure 12 below, data for Research Questions 1 and 3 were gathered during quantitative data collection in Phase 1.

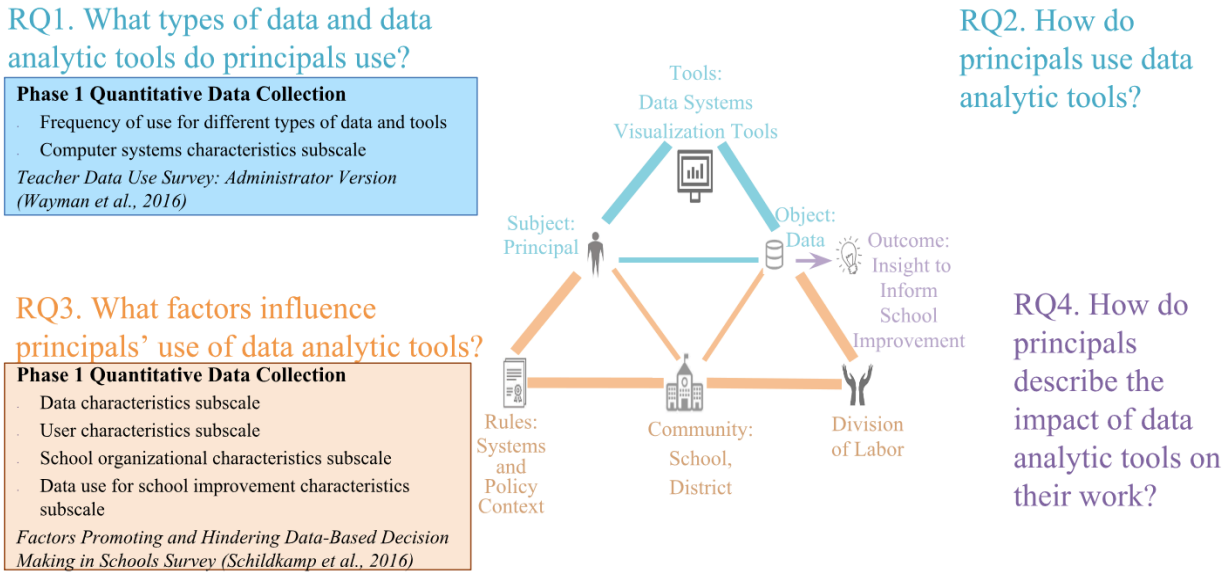

Figure 12. Alignment of quantitative data collection to research questions and framework.

Phase Two Instrumentation

The purpose of collecting qualitative data in Phase 2 was to gain a deeper understanding of trends uncovered in Phase 1 and to answer the remaining research questions surrounding the way tools were used (RQ2 and RQ4). The primary instrument used for data collection in qualitative research is the researcher (Ary et al., 2013). Because the purpose of this study was to understand the lived experience of principals, an instrument flexible enough to capture the complexity of human experience was necessary; and the literature has suggested that "only a human instrument is capable of this task" (Ary et al., 2013, p. 452). The researcher began Phase 2 by conducting a document analysis of the publicly available academic plans from the six principals who had agreed to participate in Phase 2. The purpose of the document review was to provide context for the think-aloud protocol, observation, and semistructured interview. The observations and think-aloud sessions in Phase 2 were designed to capture data on principals' experiences while interacting with the data visualization tools. The final phase of semistructured interviews provided an opportunity to gather explanatory data to confirm or expand upon the themes identified in the data from the earlier phases. All types of qualitative data—document analysis, think-aloud protocol, observation, and semistructured interview—were triangulated to deepen understanding of how principals used data analytic tools (RQ3) and how they described the impact of these tools on their work (RQ4). The semistructured interview questions were stated in an open-ended format to encourage participants to elaborate on their thoughts and provide rich details that aligned the research questions in a way that was impossible with the closed-ended questions on the survey tool. Figure 13 shows the alignment of questions with the conceptual framework.

Document analysis. In deciding whether to include documents and artifacts, the researcher considered whether documents containing information relevant to the research question could be acquired in a practical and systematic manner (Merriam & Tisdell, 2015). The researcher analyzed the publicly available academic plan documents associated with each of the six principals who had agreed to participate in Phase 2 because they could be easily obtained from the district website and provided contextual information for the semistructured interviews. These documents were downloaded from the district website in PDF format. The academic plan documents varied in stylistic ways but typically listed the major needs identified by the school community, the academic goals, and indicators of progress for each goal. Reviewing the indicators of progress published on each plan, the researcher tailored the

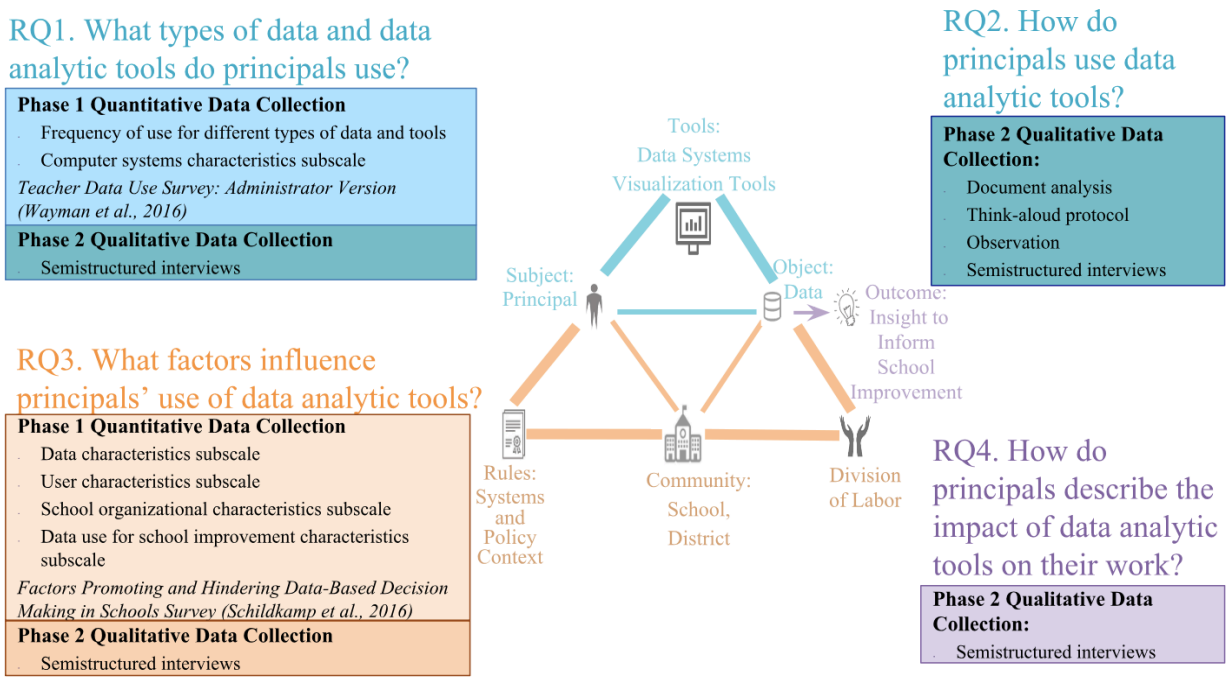

Figure 13. Alignment of qualitative data collection with research questions and framework.

questions in the qualitative data collection phase to learn more about the unique measures used by that school. For example, if the indicator of progress included a benchmark assessment for students, the researcher was able to ask, "Can you tell me a little bit more about how you analyze the data from your benchmark assessment?"

Think-alouds. Six principals who used a variety of tools were invited to demonstrate their use of the tools while narrating their thought process in a think-aloud session during Phase 2. Think-aloud data allowed the researcher to gain access to information that a respondent might not have revealed during an interview, which can be subject to respondent bias and different levels of self-awareness (Schildkamp & Kuiper, 2010). Individual observations and think-alouds focused directly on observing principals using the tools in the ways they found useful while describing their activity. Many user-centered studies of electronic information resources include a think-aloud while users complete tasks (Ericsson & Simon, 1980) in order to offset the bias or lack of self-awareness in interviews alone (Schildkamp & Kuiper, 2010). Think-aloud sessions often provide researchers with the most complete and detailed description of the users' cognitive activities (Branch, 2000). Participants were encouraged to speak openly, and the researcher made a point not to interrupt unless specifically asked a question. If the participant gave consent to audio record, then the think-alouds were recorded with an audio recorder and transcribed afterward. The overall time spent could not be precisely determined ahead of time (Merriam & Tisdell, 2015), but an estimate of 30 minutes was set aside per participant. The think-aloud protocol appears in Appendix H along with the semistructured interview questions.

Semistructured interviews. Semistructured interviews enabled the researcher to follow up with questions that arose during the think-alouds and gain additional insights into the meaning

the participants ascribed to their experiences in their own words (Turner, 2010). The semistructured interviews lasted 30 minutes and took place immediately following the think-aloud as a way to gather information that could not be obtained through the observation and as a window into participants' thinking about their actions and choices. The goal was to collect additional information about data use, the role of supporting tools, and factors affecting use. The semistructured interviews were conducted in a probing and open-ended style to allow for the interviewer to modify the format and questions during the interview process. The questions were designed in advance to avoid leading or confusing wording. Probes such as "Can you tell me more?" or "Can you provide an example?" were used along with pauses to encourage the participants to share more detail. An audio recording device was used with the participants' permission in order to avoid the distraction of taking notes during the semistructured interview and allow time for the researcher to transcribe the verbatim responses afterward. Pseudonyms were used in the transcriptions to protect privacy, and all speech was recorded, including partial utterances, overlapping speech, and other sounds as recommended in the literature (Ary et al., 2013; Hogan, Dolan, & Donnelly, 2009). The researcher carefully listened not only to what the participants said, but also noted the way they said it along with their nonverbal cues (Ary et al., 2013).

Field notes. The goal of observations is a description of the behavior, the setting, and the interactions as a firsthand account from the researcher instead of a secondhand account obtained in an interview (Merriam & Tisdell, 2015). Observations ideally take place in a setting where the phenomenon of interest naturally occurs instead of a location set by the researcher (Merriam & Tisdell, 2015). Observations allow opportunities for the researcher to compare words and actions

in determining "whether what is said actually matches actions or may illuminate subtleties that may be beyond the consciousness of the person or that the person cannot articulate" (Ary et al., 2013, p. 459). Studies on data use have sometimes indicated a disconnect between how principals reported using data on surveys and how researchers saw them using data, underscoring the importance of observing data use in action (Wayman et al., 2007). Observation sessions in this study lasted about 30 minutes, falling within the recommended time frame; otherwise the data becomes too unwieldy to record and process (Ary et al., 2013).

In determining what to observe, the researcher considered the theoretical framework, the problem, and the questions of interest (Merriam & Tisdell, 2015). Field notes were collected during the observations and semistructured interviews with as much description as possible and then elaborated as soon as possible after the observation while the experience was still fresh in the researcher's mind (Merriam & Tisdell, 2015). Field notes were separated into two components: (a) descriptive information, which captured details of the setting, actions, participants' reactions, and account of events (who, what, when, where); and (b) observer comments, including the researcher's reflective impressions about the events, thoughts about problems that arose, and speculations about data analysis (Merriam & Tisdell, 2015). Pseudonyms were used in field notes so that no identifiable names were recorded to protect the confidentiality of participants. The researcher took notes throughout the think-aloud and semistructured interview on observations and thoughts. The purpose of collecting multiple types of data was to increase structural corroboration and opportunities for triangulation (Creswell, 2008b). The field notes template that was used in Phase 2 appears in Appendix I.

Data Collection

Prior to data collection, the researcher submitted a research application with all related protocols to obtain approval from the Institutional Review Board (IRB) at the university (see Appendix J) as well as the participating district (see Appendix K). All data collected were kept confidential and secure on the researcher's password-protected computer. Anonymity was maintained in reporting by using pseudonyms in order to protect the privacy of participants. The two key phases of data collection are outlined below.

Phase 1 Quantitative Data Collection

An online survey was administered in March 2018. To ensure a variety of perspectives, all 256 public school principals in the state of Hawai'i were invited via email to participate. The text of the email invitation is located in Appendix L; the district research approval letter was included in the email invitation as an attachment as well. The email explained the purpose of the research, the benefit of the study, and the nature of confidentiality. In the email, participants were asked to click the online survey link if they were willing to complete the survey. The link took them to the consent form (see Appendix M) before continuing to the survey. Data from the survey was stored in the survey tool, SurveyShare, which was password protected and accessible only to the researcher. The collected survey data remained confidential throughout the duration of the study. The survey was open for a month with an email reminder (see Appendix N) sent at the two-week midpoint to all principals. Hard copies of the survey invitation and HIDOE research approval letter were provided to district office staff as an option available to principals to promote higher response rates (Wayman et al., 2016). Once the principals completed the

survey, an appreciation message appeared on the screen to thank them for their time and participation.

Phase 2 Qualitative Data Collection

At the end of the survey, respondents were asked whether they were willing to participate in Phase 2—the think-aloud and interview—and if so, they could provide contact information. Nineteen principals indicated their willingness to participate in Phase 2 of the research, and a purposive sampling was selected based on maximum variety in user characteristics. Any volunteers who worked in the same geographic area as the researcher were removed to avoid bias. Using their preferred contact information, the researcher emailed each principal with additional information about the voluntary nature of the observation and interview in Phase 2, the estimated length of time (60 minutes total), and the potential benefit of the study (see Appendix O). If the participant expressed interest, a confirmation email was sent to verify logistics (see Appendix P). While explaining the purpose of the study and the manner of data collection, the researcher established rapport with the participants by being friendly and honest but not overly technical or detailed (Merriam & Tisdell, 2015). A second consent form (see Appendix Q) was provided electronically to each participating principal with a message indicating that the consent form would be signed and collected at the time of the think-aloud, observation, and interview session. The researcher worked with participants to identify locations that were comfortable and convenient for each individual and ideally free from distractions (Creswell, 2008a), such as an office or conference room at their school. The space was set up with a computer or tablet provided by the participant or the researcher, and an audio recorder provided by the researcher. No additional equipment or funds were acquired to complete this

research, so any travel costs to conduct interviews on another island were paid for by the researcher. Voluntary participation of each participant was confirmed through the consent form. All participants were asked whether they were comfortable with the researcher using an audio recording device, and if consent was granted, it was repeated aloud at the beginning of the audio tape. The audio recording was used only for the researcher to transcribe what was said, and once the research was complete, the audio file was destroyed. To initiate the think-aloud, participants were asked to demonstrate their interactions with computer systems that they used for data analysis, and during this time the researcher served as a nonparticipant observer and recorded notes using a simple template to capture descriptive notes as well as reflective notes. If student data were displayed on the screen, the researcher did not record those details. Once the think-aloud and observation were complete, the researcher transitioned to the semistructured interview questions. After the interview, the researcher thanked each participant with a gift of a box of macadamia nuts to express appreciation for the participant's time.

Data Analysis

The researcher followed the major data analysis steps suggested for a mixed methods explanatory sequential design: (a) collect the quantitative data; (b) analyze the quantitative data; (c) design the qualitative strand based on the quantitative results; (d) collect qualitative data; (e) analyze qualitative data; and (f) interpret how the connected results answer the quantitative, qualitative, and mixed methods questions (Creswell & Plano Clark, 2011). During the qualitative phase, instead of waiting until the end of data collection, the researcher took an inductive analysis approach to reflect on the meaning of what was heard in order to develop hunches (working hypotheses) about what was meant throughout the study.

Phase 1 Quantitative Data Analysis

Once the survey window closed, the researcher prepared the data, exported it from the survey tool into an Excel spreadsheet, and organized the file to be imported into SPSS, the statistical software. Scoring the data entailed assigning a numeric score to each value in order to quantify the responses (Creswell, 2008a), and because summing the scores was unnecessary, the researcher assigned a single-item score to each answer aligned with a Likert scale. The next step in cleaning the data was to inspect the file for scores that were not valid or perhaps missing from the dataset (Creswell, 2008a). In order to represent general trends, frequency data and descriptive statistics were used, including measures of central tendency, such as the mean. The measures of variability, such as the range and standard deviation, indicated the spread of scores (Creswell, 2008a). Tables and charts were generated, using both SPSS and Tableau. Based on the data analysis, the researcher decided which participants to invite to Phase 2 and what results required further explanation (Creswell & Plano Clark, 2011). Major findings from the Phase 1 quantitative data analysis were recorded into summary statements with implications for the Phase 2 qualitative data collection.

Phase 2 Qualitative Data Analysis

Qualitative data were organized by pseudonyms and material type (document analysis, think-aloud, observation, and interview). Tables were created to organize the data collected from the various sources, such as the audio transcripts, document analysis, and observation notes. The organization of the data into tables helped the researcher triangulate the data and look for commonalities (Creswell, 2008b). The researcher personally transcribed all audio recordings as a way to more deeply process what was said. Transcriptions were reread several times in order to

check for accuracy and develop codes that best captured the meaning of what participants expressed. Nvivo software was used to create a codebook and mark the evidence in alignment with each code. The audio recordings from the think-aloud sessions were analyzed along with the information from the semistructured interviews for common patterns of actions, unique behaviors, or actions that seemed incongruent with the verbal descriptions. After reviewing the list of generated codes from each source, the researcher clustered codes into larger categories and identified emerging themes (Creswell, 2008a; G. W. Ryan, 2005). Direct quotations were used during the data analysis and summary of qualitative findings in order to deepen the portrayal of the meaning of the data. The findings from the qualitative analysis in Phase 2 built on what was learned from the quantitative analysis in Phase 1 and provided an opportunity to confirm or disconfirm early hunches from Phase 1 as part of the inductive data analysis process. Themes and findings were related to the conceptual framework in order to answer each research question. The final step was to integrate the quantitative and qualitative results into a coherent conceptual framework.

Validity, Reliability, and Rigor

The validity of the survey instrument in this study was established through previous studies of the two tools from which it drew. Reliability means that scores from an instrument are stable and that consistent responses are generated when an individual answers closely related questions (Creswell, 2008b). Validity means that the scores from an instrument make sense, are meaningful, and enable the researcher to draw conclusions (Creswell, 2008b). “Factors Promoting and Hindering Data-Based Decision Making in Schools” (Schildkamp et al., 2016) was peer reviewed by four teachers and five expert researchers in the field, piloted in three

schools, and then used in a large-scale study with 1,073 respondents. Confirmatory factor analyses and reliability analysis revealed consistency with the authors' theoretical framework and strong Cronbach's alpha results. The Teacher Data Use Survey created by Wayman et al. (2016) was developed by a panel of researchers who were experts in data use, drew heavily upon previous iterations of the survey (Deike, 2009), and was piloted in Metropolitan Nashville Public Schools before becoming publicly available for use. Previous studies have shown that the Cronbach's alpha for each scale was 0.85 or higher, but in order to confirm the reliability of the subscale scores generated by this survey, the researcher ran Cronbach's alpha analyses as well. A potential threat to validity was that survey respondents to an online survey are already more likely to be technology users and not fully representative of the population.

Qualitative data and data collection methods must be subject to checks and balances in producing trustworthy results (Merriam & Tisdell, 2015). Questions in the semistructured interview were worded neutrally and sequenced to reduce misunderstanding or bias that would lead the participants to certain responses (Creswell, 2008b). A semistructured interview protocol was used to strengthen the consistency of procedures across multiple sessions. Audio recordings were transcribed and then checked for accuracy. Findings were returned to the participant to check the accuracy of the interpretation. This practice of member checking was consistent with the underlying belief in qualitative inquiry that reality is what participants perceive it to be, so member checks strengthened the validity of the findings based on the participants' perspectives (Creswell, 2008b).

Triangulation is a means to investigate a phenomenon with more than one approach in order to maximize the validity of the data and enhance confidence in the findings. The researcher

collected multiple types of data using multiple means for methodological triangulation and data triangulation. Other researchers in the field of educational technology have found that triangulation of multiple data sources was a valuable step to confirm or question self-reported use of the technology (Gorissen, van Bruggen, & Jochems, 2013). Another step the researcher took to strengthen the trustworthiness of analysis was to return to the transcripts and codebook on different days to recode the original transcripts as a way of checking on intrarater agreement and consistency. The researcher made notes throughout the study in order to record personal thoughts, feelings, and rationale for decisions made in order to monitor potential bias.

Summary

This mixed method study was designed to explore the experiences of principals using data analysis tools. Two phases of data collection were used as part of a sequential explanatory design. This study has provided a deeper understanding of what data and what tools principals used, how they used them, what factors influenced their use, and how their use informed decisions for school improvement. The next chapter contains the findings.

CHAPTER 4. FINDINGS

This chapter includes five sections, the first of which describes the population studied, followed by a section for the findings aligned with each of the four research questions:

RQ1. What types of data and data analytic tools do principals use?

RQ2. How do principals use data analytic tools?

RQ3. What factors influence principals' use of data analytic tools?

RQ4. How do principals describe the impact of data analytic tools on their work?

In each section, the quantitative data are described, followed by a description of the findings from the qualitative data, which were derived from an online survey. The purpose of the survey was to discover the frequency of use of the various types of data and tools as well as to obtain measures for the following scales: computer systems characteristics, data characteristics, user characteristics, school organizational characteristics, and data use for school improvement. After the survey data were collected, each scale was tested for internal reliability using Cronbach's alpha. Table 2 shows a comparison of the results of this research with those found in the literature, which were all above 0.70 and within the range of acceptable consistency.

Table 2. *Reliability of the Survey Scales*

Scale	**Number of Items**	**Cronbach's alpha in this study**	**Cronbach's alpha in the literature**
Computer system characteristics	5	0.88	0.85
Data characteristics	10	0.75	0.85
User characteristics	8	0.86	0.80
School organization characteristics	16	0.92	0.92
Data use for school development	9	0.78	0.87

The qualitative data were derived from a variety of sources, including open-ended survey questions and document analysis of school academic plans as well as face-to-face think-aloud and interview sessions.

Population

The online survey was initially sent to the email addresses of 256 principals in the Hawai‘i Department of Education, but one email bounced back as undeliverable. Seventy responses in total were collected from the online survey, representing roughly 27% of the population. Notable events at the time of the data collection included an educational research-related issue in the local news as well as a volcanic eruption that may have negatively influenced participation. Table 3 shows a summary of the demographic data for the survey participants. Slightly more females (n=36) than males (n=32) participated. The majority of participants identified as Generation X-ers (born 1965–1978) and Baby Boomers (born 1946–1964), which

Table 3. *Demographic Data of Survey Population (N=70)*

Demographics		Frequency	Percent
Gender:			
	Female	36	52.2
	Male	32	46.4
	Other	1	1.4
Generation:			
	Baby Boomers (born 1946–1964)	33	48.5
	X-ers (born 1965–1978)	30	44.1
	Echoes (born 1979–1990)	3	4.4
	Declined to specify	2	2.9
Island:			
	Oahu	40	58.8
	Hawai‘i	16	23.5
	Maui	6	8.8
	Kauai	3	4.4
	Molokai	3	4.4

was unsurprising because principals typically serve in leadership roles that tend to attract experienced educators. Over half the respondents lived on Oahu (58.8%), which was consistent with the demographic distribution in the state.

Eighteen survey respondents indicated interest in participating in Phase 2 of the research. To avoid bias and dual relationships, the four respondents of the 18 who worked in the same geographic area as the researcher were removed from the list of eligible candidates. After reviewing the demographic characteristics of the remaining 14 participants who had expressed interest, six participants were invited based on maximum variation. Of the six participants originally selected for maximum variation, two were nonresponsive to follow-up invitations; so two others were selected from the list to secure as much variation as possible in the following order of priority: user characteristics, generation, geographic location, school level, and gender. The most important variation sought among the interviewees was the mean calculated from their self-reported scores on the user characteristics scale in the survey. Two participants, who had a high mean of 5, were selected; in other words they strongly agreed with every statement indicating confidence in data use. Two interviewees were in the medium range with a mean between 4–4.5, and two were in the relatively low range with means below 4. The participants represented several generations with three Baby Boomers (born 1946–1964), two Generation X-ers (born 1965–1978), and one who identified with the Echo generation (born 1979–1990). In Phase 2 three islands were represented by three interviewees from the island of Oahu, two from the island of Hawai‘i, and one from the island of Maui. Half were from elementary schools, one was the leader of a middle school, and two were leaders of high schools. Five of the interviewees were male, and one was female. Overall, more males had volunteered for Phase 2 than females.

When the other female invitees were nonresponsive and the next volunteers who satisfied the other demographic specifications were selected, the result was more male interviewees. Presenting all the demographic information of interview participants in a table would compromise anonymity, but the self-reported user characteristics and generational data are shown in the table below to provide valuable context for the qualitative data.

Table 4. *User Characteristics, Generation, and Gender of Interviewees*

	Range of User Characteristics Scale Mean from the Survey	**Generation**	**Gender**
Principal 1	Medium 4–5	Generation X (1965–1978)	Male
Principal 2	Low < 4	Baby Boomer (1946–1964)	Female
Principal 3	High = 5	Echo (1979–1990)	Male
Principal 4	Low < 4	Baby Boomer (1946–1964)	Male
Principal 5	Medium 4–5	Baby Boomer (1946–1964)	Male
Principal 6	High = 5	Generation X (1965–1978)	Male

Research Question 1: Types of Data and Tools Principals Used

In response to the first research question, the researcher explored the types of data and the data analytic tools used by principals with data collected from an online survey and more in-depth explanations in the semistructured interviews.

Quantitative Results for RQ1

In the survey, principals were asked to indicate the frequency of use of various types of data. Specific forms of data listed on the survey were inspired by a study entitled *A Comparison of Secondary Principals' Use of Data Systems to Increase Student Achievement in Mathematics as Measured by Standardized Assessments* (Williams, 2011). The Likert scale used to measure frequency of use derived from the Teacher Data Use Survey: Administrator Version (Wayman et al., 2016). The quantified scale included the following points: 1 (*do not use*), 2 (*less than once a*

month), 3 (*once or twice a month*), 4 (*weekly or almost weekly*), and 5 (*a few times a week*). Results appear in Table 5 in descending order by mean so that the types of data with the highest frequency of reported use appear at the top. The standard deviation indicates the amount of variation: A lower standard deviation indicates that the data tends to be close to the mean, and a higher standard deviation indicates that the data points were spread over a wider range. The boxes in the table are proportional in size to the distribution of responses to support visual detection of patterns.

Table 5. *Frequency of Use by Types of Data (N=70)*

Data Type	Do not use = 1	Less than once a month = 2	Once or twice a month = 3	Weekly or almost weekly = 4	A few times a week = 5	Mean	Std. deviation
Teacher observation data		21.4%	35.7%	31.4%	11.4%	3.33	0.94
Student attendance data		25.7%	40.0%	25.7%	8.6%	3.17	0.92
Data about best practices for instruction	4.3%	24.6%	36.2%	26.1%	8.7%	3.10	1.02
Resources management data	1.4%	26.1%	40.6%	29.0%	2.9%	3.06	0.86
Feedback from teachers	1.4%	34.3%	34.3%	24.3%	5.7%	2.99	0.94
Effectiveness of school programs	7.2%	26.1%	43.5%	18.8%	4.3%	2.87	0.95
Other	29.4%	11.8%	23.5%	17.6%	17.6%	2.82	1.51
Teacher-generated authentic assessment data	11.4%	34.3%	27.1%	17.1%	10.0%	2.80	1.16
Student growth data	4.3%	35.7%	42.9%	15.7%	1.4%	2.74	0.83
Data about curriculum needs	4.3%	38.6%	42.9%	14.3%		2.67	0.77
Benchmark assessment data	10.0%	30.0%	47.1%	10.0%	2.9%	2.66	0.90
Universal screener data	7.1%	35.7%	47.1%	4.3%	5.7%	2.66	0.90
Student language data	2.9%	55.1%	31.9%	10.1%		2.49	0.72
Feedback from students	10.1%	43.5%	36.2%	10.1%		2.46	0.81
School performance data	4.3%	62.3%	24.6%	8.7%		2.38	0.71
Standardized test scores		68.6%	25.7%	5.7%		2.37	0.59
Perceptions of the learning environment	5.7%	70.0%	18.6%	5.7%		2.24	0.65
Report card data	13.2%	66.2%	13.2%	4.4%	2.9%	2.18	0.83
Student socioeconomic data	11.4%	72.9%	14.3%	1.4%		2.06	0.56
Student ethnicity data	17.4%	73.9%	5.8%	2.9%		1.94	0.59
Student gender data	26.1%	68.1%	2.9%	2.9%		1.83	0.62

At least 30% of principals reported using five types of data weekly (rating of 4 or 5). These included teacher observation data (42.8%), student attendance data (34.3%), data about best instructional practices (34.8%), resource management data (31.9%), and feedback from

teachers (30%). Comparatively, feedback was used more if it had come from teachers (*M*= 2.99) instead of students (*M*= 2.49); in fact, 10% of principals reported using no student feedback.

Five student learning indicators trended in the middle of the list. The majority of principals reported using this type of data in the range of less than once a month to twice a month (rating of 2 or 3). These included student growth data (78.6%), teacher-generated authentic assessment data (61.4%), data about curriculum needs (81.5%), benchmark assessment data (77.1%), universal screener data (82.8%).

Half or more of the principals used nine types of data less than once a month (rating of 1 or 2), including student language data (58%), feedback from students (53.6%), school performance data (66.7%), standardized test scores (68.6%), perceptions of the learning environment (75.7%), report card data (79.4%), student socioeconomic data (84.3%), student ethnicity data (91.3%), and student gender data (94.2%). The bottom three are related to student-level demographics.

The category Other generated the highest percentage of responses on the two extreme ends of the scale with 17.6% indicating they use other data types frequently throughout the week and 29.4% indicating that they do not use other data at all. When principals specified what Other meant, they added responses like discipline data, walk-through data, response to intervention (RTI) data, and culturally relevant assessment data, including alternate measures of cultural expression.

Generating composite means for frequency of use is possible by organizing the list from the survey into a visual adapted from Bernhardt's (2018) multiple measures of data with the

following four categories: demographic data, student learning data, school process data, and perceptual data as shown Figure 14. Demographic data, comprising student attendance,

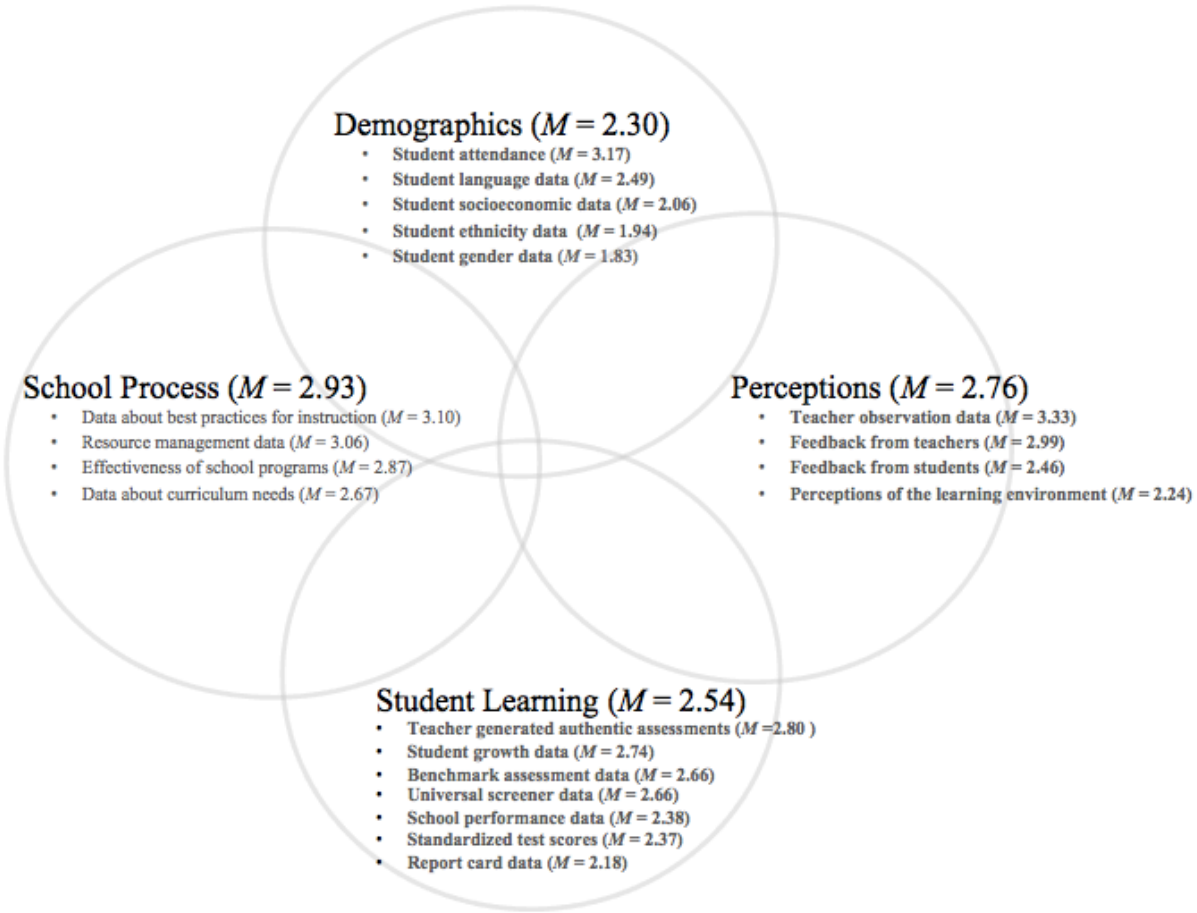

Figure 14. Composite frequency of use by data type.

language, socioeconomic, ethnicity, and gender data, had the lowest composite mean at 2.30, which means principals generally used that type of data less than once a month. Student learning data, a category consisting of teacher-generated authentic assessments, student growth data, benchmark assessment data, universal screener data, school performance data, standardized test scores, and report card data, yielded a composite mean of 2.54, slightly closer to use once or

twice a month. Perceptions, including teacher observation data, feedback from teachers, feedback from students, and perceptions of the learning environment, produced a composite mean of 2.76, close to a rating of 3 (*once or twice a month use*). School process data, including data about best practices for instruction, resource management data, effectiveness of school programs, and data about curriculum needs, resulted in the highest composite mean of 2.93. Although individual types of data were used more frequently, the overall composite means of each category of data fell between 2 (*less than once a month*) and a 3 (*once or twice a month*); none of the individual data types or composite categories garnered a mean above 4 (*weekly or almost weekly*).

An array of tools was used to work with a variety of types of data. The list of tools provided in the survey reflected those supported by the district at the time of the study in addition to tools that the researcher knew were commonly purchased or used by principals. The scale measuring frequency of use derived from the Teacher Data Use Survey: Administrator Version (Wayman et al., 2016) and included a 5-point Likert scale quantified as follows: 1 (*do not use*), 2 (*less than once a month*), 3 (*once or twice a month*), 4 (*weekly or almost weekly*), 5 (*a few times a week*). Results appear in Table 6 in descending order by mean so that the tools with the highest frequency of reported use appear at the top.

Four tools were used by the majority of principals on a weekly basis (rating of 4 or 5). Google Suite stood at the top (80%), followed by Excel spreadsheets (58%), Infinite Campus (51.5%), and tools generated at the school level (50.8%). The greatest diversity of responses was generated around using school-based tools with the highest standard deviation and more than one fifth of principals (22%) reporting not using school-based tools at all.

Table 6. *Frequency of Use for Digital Data Tools (N=70)*

Tool	Do not use = 1	Less than once a month = 2	Once or twice a month = 3	Weekly or almost weekly = 4	A few times a week = 5	Mean	Std. deviation
Google Suite	2.9%	5.7%	11.4%	21.4%	58.6%	4.27	1.06
Excel spreadsheets	5.8%	15.9%	20.3%	34.8%	23.2%	3.54	1.18
Infinite Campus	7.4%	20.6%	20.6%	20.6%	30.9%	3.47	1.32
School-based	22.2%	12.7%	14.3%	25.4%	25.4%	3.19	1.51
eCSSS	11.4%	22.9%	28.6%	17.1%	20.0%	3.11	1.29
PDE3	6.0%	19.4%	47.8%	20.9%	6.0%	3.01	0.95
LDS	5.7%	51.4%	28.6%	11.4%	2.9%	2.54	0.88
ARCH	2.9%	61.4%	30.0%	4.3%	1.4%	2.40	0.69
HSAP	10.0%	60.0%	24.3%	5.7%		2.26	0.72
iReady	62.3%	4.3%	18.8%	13.0%	1.4%	1.87	1.21
Other	69.2%		15.4%	7.7%	7.7%	1.85	1.41
Renaissance Learning	55.9%	19.1%	17.6%	7.4%		1.76	0.99
AVA System	54.3%	37.1%	4.3%	4.3%		1.59	0.77
SchoolView	63.8%	33.3%	1.4%	1.4%		1.41	0.60
Jupiter Grades	94.3%	1.4%		2.9%	1.4%	1.16	0.69

The trend in the middle of the list consisted of five tools provided by the district to perform specific functions and used by principals monthly or less than once a month (rating of 2 or 3). The list included the electronic Comprehensive Student Support System (eCSSS) (51.5%), the teacher evaluation and professional development platform (PDE^3) (67.2%), the Longitudinal Data System (LDS) (80%), Accountability Resource Center Hawai‘i (ARCH) (91.4%), and Hawai‘i State Assessment Portal (HSAP) (84.3%).

Tools unused by the majority of principals (rating of 1) comprised mostly those unsupported by the district with the option to purchase at the individual school level. This list included iReady (62.3%), Renaissance Learning (55.9%), the AVA interim assessments (54.3%), SchoolView (63.8%), Jupiter grades (94.3%), and tools that did not appear on the survey list but could be specified under Other (69.2%). The additional tools named by principals included Tableau, Achieve 3000, Edginuity MyPath, along with those that were school-based like a school

data matrix. The quantitative data collected from the Phase 1 survey was the main focus of data collection for RQ1; however, qualitative data added additional depth to the understanding of what data and data tools were used by principals.

Qualitative Results for RQ1

Qualitative data were synthesized from the open-ended survey questions that came from the 70 survey participants in Phase 1 along with the data from the six participants interviewed in Phase 2. Examples of types of digital tools they described using to collect, organize, analyze, and share data were organized by the source of the tools in Figure 15. The tools mentioned by interviewees mostly confirmed what was found in Phase 1 with the addition of a few more tools selected at the school level and varying from school to school.

Platforms Supported by the District	**Examples of Tools Selected at the School Level**			
	Subscriptions Purchased by the School	**Software Purchased by the School**	**Created in-house**	**Free**

• Longitudinal Data System (LDS)
• AlohaHSAP
• ARCH Database
• eCSSS
• FRS
• PDE^3
• Infinite Campus
	• iReady
	• STAR
	• Achieve3000
	• Accelerated Reader
	• Naviance
	• ReadingPlus
	• Fontus and Pinel Benchmarks
	• Jupiter Grades
		• Excel
		• Numbers
		• School Synergy
		• On Site School Review
		• Accelus
		• Tableau
			• Databases created in house
			
			* Pencil and Paper systems such as Cumulative Folders
			* Student Profiles
			* Interviews
			
			(*Not digital tools)
				• Google Suite
				  • Forms
				  • Sheets
				  • Docs
				  • Calendar
				• MyFuture Hawaii

Figure 15. Types of tools from Phase 2 qualitative data organized by the source of the tool.

During the interviews, principals shared thoughts about district–supported tools, such as the statewide assessment portal for standardized test reporting called AlohaHSAP, the ARCH accountability database, the electronic Comprehensive Student Support Site (eCSSS), the

Financial Reporting System (FRS), a professional development and evaluation platform (PDE^3), a student information system (Infinite Campus), an email and business application system (Lotus Notes), and the Longitudinal Data System (LDS). Principals often used the LDS to analyze student demographic data as observed in the segment from the think-aloud that follows:

> So look at our Micronesian population, but even our Asian population. That's our next highest. And, you know, Native Hawaiian. You know, um, part Hawaiian, but a lot of them, they're all mixed, right? So I don't know how they really tell $1/18^{th}$? Okay, this breakdown is good. We're getting, um, Hispanic. Okay, Chinese, Filipino, Japanese, 24%, 38%, still a lot you know. Okay, now low SES. We're in the high 70s but still not enough to have the whole school as free lunch. Okay, so look at this our IDEA/SPED. Wow. So I got to watch because now we're going to start getting counted because enrollment is going up. (Principal 2)

Some principals stated that they used district-supported tools differently, depending on what level of school they led. For example, one principal explained that he used the eCSSS tool mainly for discipline at the secondary level and mainly for special education (SPED) documentation at the elementary level:

> So at the secondary level I seemed to use eCSSS a lot because there was a lot of inputting of student discipline issues and those kind of things that we were inputting there more. So then at elementary, where we don't have as many, we use it more for SPED. (Principal 1)

Needs vary school by school, and each principal has the autonomy to purchase her or his own tools with school-level funds in addition to accessing those supported by the district. Many mentioned contracts supported by outside providers for ongoing subscriptions of universal

screeners, such as iReady and STAR; grading platforms, such as Jupiter Grades; college support tools, such as Naviance; and tools that supported instruction and formative assessment, such as Achieve3000, Reading Plus, and Fountas and Pinnell Benchmarks. In addition to subscriptions that were mainly cloud-based, principals also described purchasing software like Excel, Numbers, Accelus, Tableau, and School Synergy's OnSite School Review. Another category of tools included those generated in-house at the school to share information and those databases created because none were available to capture data of interest. Confirming what was found in Phase 1 of this study, principals shared most frequently their use of free tools from Google Suite, including Google Forms, Google Sheets, Google Docs, and Google Calendar. The following example demonstrates how Google Forms were used to track process data involving positive behavior supports. (In all quotations that follow … indicates a pause, and — indicates a break in thought.)

> What we do is we have these things called commendations. So let me see if I can pull up that file for you. And this is—this is part of our positive behavior, PBIS system. Okay, let's see if this will show you. Okay. Oh, gosh, it's a lot. So I created this. It gets printed out onto nice paper, and essentially teachers, actually any staff member, can write up a student who is strongly displaying ... you know, one or more of these core values. And then what they do is they write in what they are trying to recognize. And they come to an administrator. So we've actually been announcing it on our weekly announcements, and then the kids come and get them. What happened is we log it in. So I created a form. This is the form where we log in, and it tells us what team, did they get it, did it come from, grade level, student name, who was it that referred them, and so these are all teachers and

then what core values. So you know, so what happens is, you know, essentially I'm just keeping those tabs, and then I will every once in a while … and then ... I didn't do this at all this year because there was just there was kind of a dying interest. But what I do is I just look at the summary of things, and I put it into a sheet. Break it up by the teams, and send it off [to] the teams so that they know which kids are receiving commendations. So that if there's kids that should be receiving one but are not, they can go, "Like, oh, how come so and so didn't get one. You know what? ... We should probably write one up for her." That's another use of data. These are all cultural aspects of the use of data. (Principal 3)

Google Suite tools provided a way for that principal to collect and analyze the data deemed locally important to them and to work with it in a collaborative manner. Many principals talked about the benefits of the Google Suite tools because they provided the flexibility to collect various kinds of data, such as perceptual data, as discussed in the following example:

For other types of data, perspective data, like, we do use Google Survey a lot, or Google Forms rather, to survey. Like, for example, we just did an evaluation of our kindergarten orientation with the parents, and so that was through a Google Form. We'll do an interest survey. And then we also use Messenger to push out the surveys. Our Wellness Committee put together a Cooking Up the Rainbow Night. And so we just did the sign ups over Google Forms, and then were able to see, you know, who signed up. Capture that data really easily. Every year we have STEM Ho'ike. For the past two years we've been having kids showcase what they're learning in STEM and their engineering design. And so—this is just simple—and it wasn't really doing a Likert scale or anything, but we

> just asked two simple questions: What do you want to see repeated? What you want to see improved? And just capturing that data there. (Principal 6)

Other staff members often factored into these activities because they shared the ability to use Google tools collaboratively.

Interviewees talked about monitoring budgets with a tool called the Financial Reporting System (FRS) and using projected enrollment count data when determining position allocations for the following school year. They also described how they used discipline data, such as suspensions and referrals, tracked mainly on the district tool called eCSSS as well as school-generated tools to track detentions and positive behavior support systems. An example of a positive behavior data point was a middle school that used a Google Form to track positive behavior shout-outs sent by students and staff members. Student learning data discussed by principals in the interviews included mainly formative assessment data, report card, and universal screener data, which confirmed information found in Phase 1. Tools that were mentioned by interviewees that would not be considered digital tools are noted in this section but are not included in further analysis of the digital tools used by principals. When principals described using perceptual data, they often referred to intentional interviews with educators and parents, along with informal anecdotal data from staff, students, and community members.

Comparison of Quantitative and Qualitative Results for RQ1

The quantitative data and qualitative data collected to answer RQ1 provided a description of the types of data principals used and the tools they used to help them make sense of their data. In comparing the datasets, nothing from Phase 2 seemed to contradict what was learned in Phase 1, but in many ways the information clarified and extended results. For example, teacher

observation data was reported to be used by 100% of principals, emerging as the most frequently used data type overall; but PDE^3, the district support tool for collecting observation data, was used less frequently and not used at all by 6% of principals. Interviewees clarified the ways that they collected informal walk-through observation data on a more frequent basis using tools like Google Suite as well as pencil and paper. Useful information can be gleaned by organizing the combined findings into the Venn diagram of Bernhardt's (2018) four main types: demographics, school process, student learning, and perceptual data. In Figure 16 the data types are listed first by those emanating from the Phase 1 survey, followed by what was added from Phase 2.

Trends in the Phase 2 data often confirmed what was found in Phase 1, such as minimal examples of using student demographic indicators like gender or socioeconomic status. Several additional data types, uncovered through the qualitative data collection, included school process data, such as budget information, position allocation data, and discipline data, which are commonly provided to all schools by the district. Other data types, such as detention, positive behavior data, interview data, and anecdotal data, were unique to individual schools and varied across locations.

A similar Venn diagram can be used to present the combined findings about which digital data analysis tools were used by principals. Overlapping the four data types in the Venn diagram created 13 regions showing (a) four data types used alone, (b) four regions with two-way intersections, (c) four regions of three-way intersections, and (d) one region in the center that intersects all four data types. Placement of the tools into a region shows which types of intersectional analysis are supported by that tool. For example, PDE^3 is a tool that contains both perceptual data, such as classroom results of the Tripod student survey, and student learning

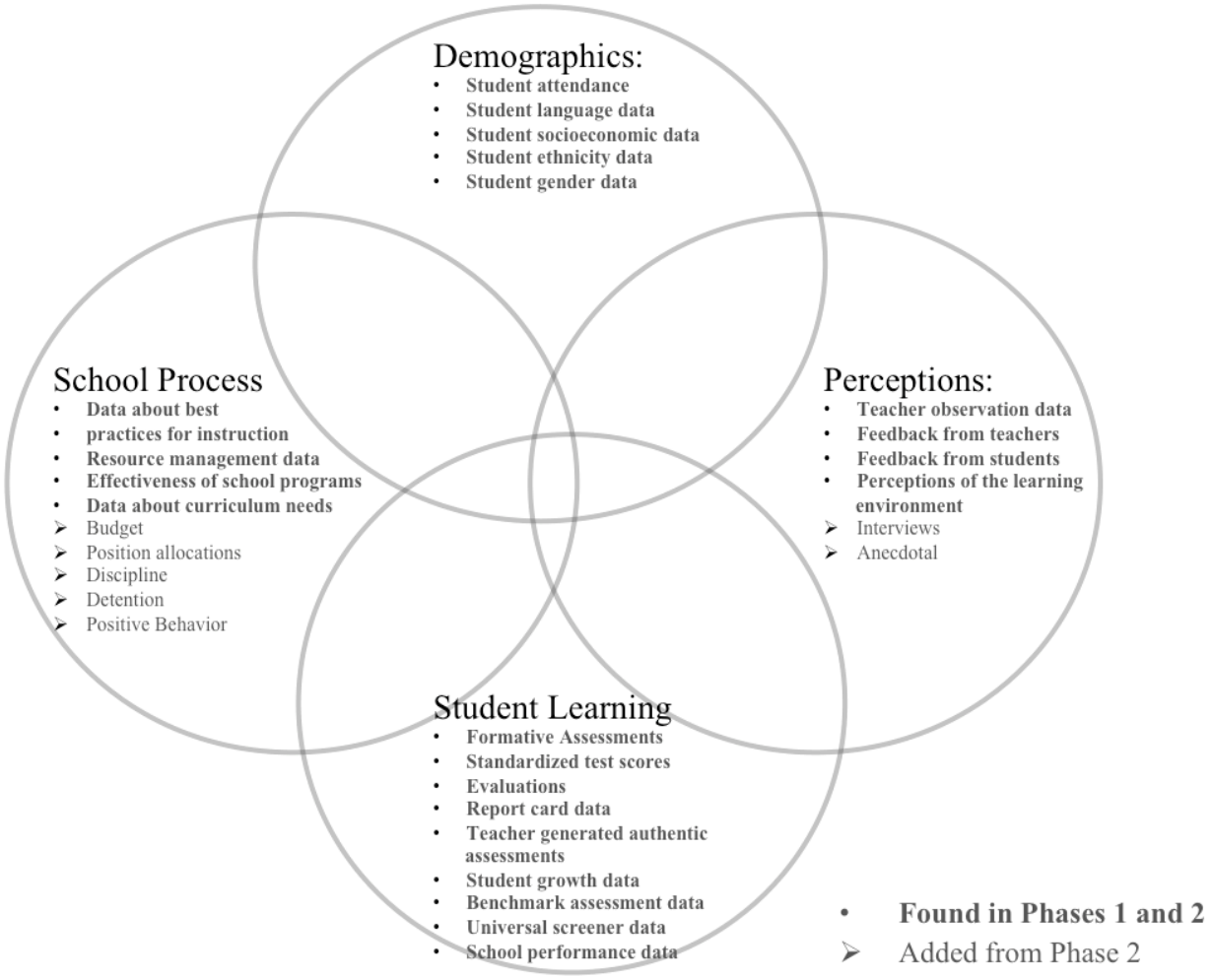

Figure 16. RQ1 findings: Types of data used

data, such as the median growth percentile of the class from annual standardized tests. General data tools, which did not naturally integrate any data types, appear on the side. A number of tools integrating demographics and student learning data did not fit into Bernhardt's (2018) Venn diagram for multiple measures because no region was available for that two-way intersection. Noted at the side in Figure 17 are Infinite Campus, ARCH, HSAP, and SchoolView, which

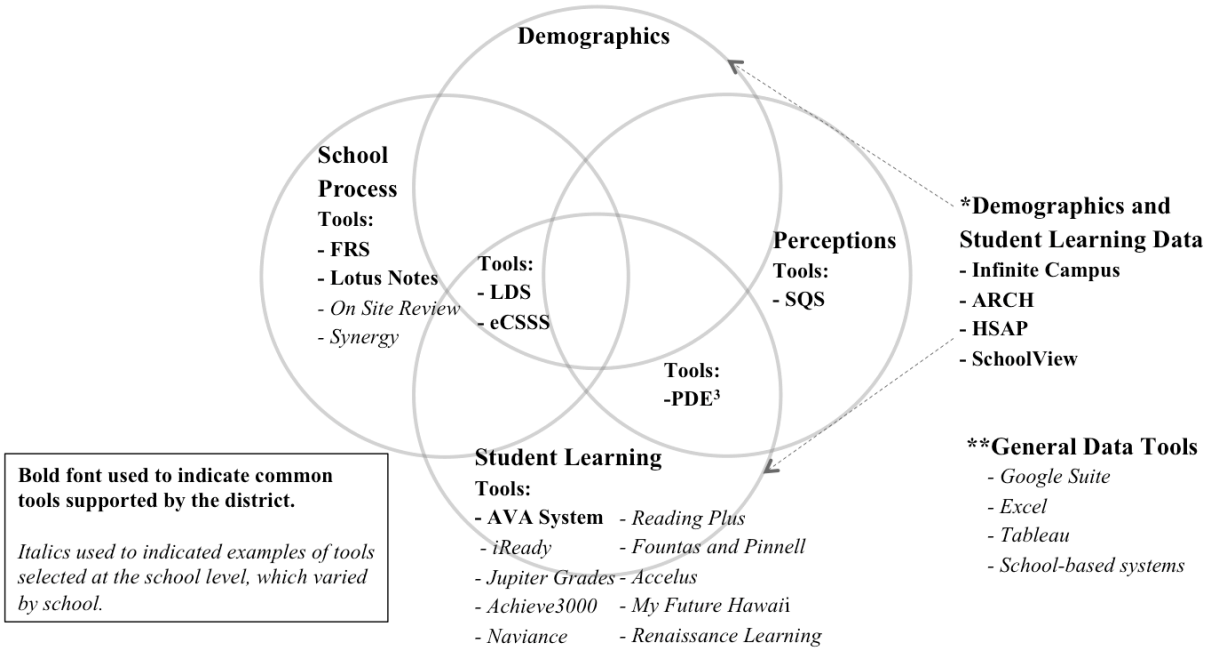

Figure 17. RQ1 findings: Digital data tools organized by type of data supported.

supported users in viewing annual student learning indicators disaggregated by a number of demographic factors. Bold and italic fonts differentiate tools commonly supported across the district versus those selected at the school level.

The majority of digital data tools supported by the district were used for student learning and demographic data analysis with limited school process and perception data. No common tools formally supported by the district for principals integrated all of the data types. Users talked about downloading data from other platforms and then inputting the data into general spreadsheet tools, such as Excel (or Numbers), Tableau, databases they create in house, or most ubiquitous of all—the Google Suite. The Longitudinal Data System (LDS) and electronic Comprehensive Student Support System (eCSSS) supported the integration of three different data types: demographic data, school process data in the form of discipline data, and student

learning from tests. Some tools supported users' exploration of very similar standardized test data and their relationship to demographic indicators, such as the Accountability Resource Center Hawai‘i (ARCH) and Hawai‘i State Assessment Portal (HSAP). This sentiment was echoed by the interviewees who said that some of the systems seemed to duplicate functions. Categorizing the tools in this way would have been difficult if simply based on Phase 1 survey results. The thick descriptions from the interviewees in Phase 2 provided clarification on how various tools integrated data. In the example below, an interviewee described the use of Infinite Campus and LDS to access both demographic data and student learning data:

> Infinite Campus for me is—I'm looking up transcripts and looking at enrollment. I can look up grades. I can go on to [a] student schedule and actually look to see if there's something going on there. So if I have any questions about that, I can use that for that. I can actually do my enrollment—some of the same things that I can do for LDS, but I'm getting better at it. So I use it as just a one-stop shop type thing, and I can go through. It doesn't do overall attendance, so I have to go back to LDS for that. I can get credit reports. I can look up whether they [students] are or aren't 504, IDEA. I can look up the transcripts as far as all the way back to—if they've been in the DOE system—how long. So, there's a lot on Infinite campus that I have access to and I go into, especially if I'm looking up kids that are coming in to me. You know, what's their history? That type of thing. So that one I use a lot. If I get a parent call, I'm immediately going in Infinite campus; and I'll look up and see what the grades were or whatever. So I have a little bit of preinformation prior to calling him back. (Principal 5)

Overall, digital tools that support analysis of perceptual data were lacking, but PDE[3] allowed for the analysis of some perceptual data and school process data mostly in the form of tracking classroom observations and professional development data. The second research question was designed to explore how data and digital tools were used for various purposes.

Research Question 2: How Principals Used Data Analytic Tools

For the second research question about the way principals used data analytic tools, the observation and think-aloud protocol along with the semistructured interviews were the main sources for data collection; however, one section of the survey from Phase 1 also provided a glimpse into the way principals used data.

Quantitative Results for RQ2

The nine items from the Data Use for School Development scale in Schildkamp's Factors Affecting Data Use Survey (personal communication, October 26, 2017) breaks down the ways that principals might use data in the context of school improvement. Principals responded to each statement on a Likert scale that included 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral*), 4 (*agree*), and 5 (*strongly agree*). The results appear in Table 7.

More than 90% of principals agreed or strongly agreed that student results were used to determine yearly goals for school improvement (97.1%) and that student results led to decisions about professional development (95.6%). More than 80% indicated that (a) they used data to show teachers the extent to which the school achieved goals (85.5%) and (b) student achievement results were used to identify curricular gaps (84%). Three fourths or more of the principals replied that detailed data analyses were essential in the improvement process (79.7%)

Table 7. Data Use for School Development Scale (N=70)

	Strongly Disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly Agree = 5	Mean	Std. Deviation
In my school we use student results to determine yearly goals for school improvement.		1.4%	1.4%	79.7%	17.4%	4.13	0.48
In my school student results lead to decisions with regard to professional development.		1.5%	2.9%	82.4%	13.2%	4.07	0.47
I show teachers based on data to what extent the school is achieving our goals.		2.9%	11.6%	73.9%	11.6%	3.94	0.62
Student achievement results are used to identified gaps in our curriculum.		2.9%	13.0%	71.0%	13.0%	3.94	0.59
Detailed data analyses are an essential part of improvement processes in my school.	2.9%	1.4%	15.9%	63.8%	15.9%	3.88	0.80
In my school we use data as a tool to determine effective teaching methods.		8.8%	16.2%	60.3%	14.7%	3.81	0.80
In our school we use external evaluations for our own improvement.	1.4%	18.8%	13.0%	53.6%	13.0%	3.58	0.99
The division of teaching time in my school is based on identified learning needs of students.	2.9%	13.2%	22.1%	57.4%	4.4%	3.47	0.89
Results of students are used to evaluate teachers.	8.7%	39.1%	24.6%	23.2%	4.3%	2.75	1.05

and that data were used to determine effective teaching (75%); about two thirds indicated using external evaluation for improvement (66.6%).

In two areas at least one third of principals were neutral or disagreed regarding data use: using external evaluations for improvement (33.3%) and division of teaching time is based on learning needs (38.2%); furthermore, nearly three fourths were neutral or negative in the use of student results to evaluate teachers (72.4%). The Data Use for School Development scale

provided some insight into the way principals made use of data, but the majority of information collected to answer RQ2 came from the Phase 2 qualitative data collection.

Qualitative Results for RQ2

As with most tools, use varied by individuals; but themes emerged across the qualitative data, indicating that principals generally used them for analysis, that is, for comparing, planning, and reporting to gain insight. These themes have been synthesized in Figure 18, and further exploration appears in the following sections.

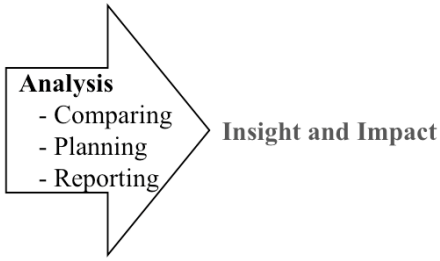

Figure 18. Uses of data analytic tools.

Use of data for comparing. Using the data tools for comparison purposes meant opening more than one data set to look for differences and similarities. Every interviewee provided examples of data comparisons of entities like time intervals, schools, teachers, groups of students, and programs. During the think-aloud one principal was observed comparing different percentages over time regarding the demographic composition of the student population using the Longitudinal Data System:

> Third grade—look at that! Last year we had 47. This year we're down to 17, … but 14. The enrollment is dropping. But that's why—you know, this whole area—like look at the enrollment. So you know how we get the six-year projection? The six year—it's going to

go down to 152. And you know what? We're pretty much on track, you know, because look at that. It keeps going down, down, down. (Principal 2)

A similar example arose when a principal looked at publicly available accountability data not only to make comparisons over successive school years but also to compare data points for various schools. Looking at the relative performance of others gives principals some context to understand their own indicators. One stated:

> Strive HI, the trend report results—these are the things I get into most often because it's just a starting point. And I can pull those all up, and I also can see other schools, and I can compare where we are with everybody else in those kinds of things. (Principal 1)

As he demonstrated his use of that tool, the researcher observed its features, such as filters, which supported comparisons of schools in similar geographic regions or with similar socioeconomic status.

Two principals described pulling data from their universal screener by teacher and comparing results across classrooms. One stated:

> So, this is iReady. It's basically—it is a wraparound universal screener plus support type of program. And essentially what we can look at is—so we schedule our kids to do a diagnostic screener three times a year. So, the data that I look at—there's a couple of reports that I consistently look at and that would be student growth. I can break it down into the teachers. Okay, so this is called the predicted proficiency. So, what this is saying is based off of our third universal screening—that they are predicting that 21% of our students' school wide will test proficient on the SBA [Smarter Balanced Assessment]. Okay? You can also look at it by grade level. So, this is—this is by math. And I can say

that in Grade 6 it did not meet this proficiency because I think we landed in the 20% range. It's really sad. Our Grades 7—I got to look up—it's been a while since they looked at the end of the year data. Our Grade 8 far exceeded this number by quite a bit. Grade 7, I'm pretty sure exceeded this number as well. However, Grade 6, I know, did not—did not meet that—even that predicted proficiency. So, the only thing I really use this data for is to communicate to staff where we are and what is being predicted to work on. What can we do to support students to either achieve that predicted proficiency or, you know, beat it? (Principal 3)

Through these comparisons, principals identified where performance might be stronger and upon reflecting on differences, they saw opportunities for professional learning among teachers. Principal 2 said:

> What I noticed with—even with the iReady [screener data]—it's like, gee, you know, since they're [a] great class, ... that's what they did. … What are you doing? You know, maybe what—maybe [teachers] are missing some things.

Half the interviewees shared specific stories, comparing one group of students to another. Often disaggregating by demographic subgroups, principals sought to understand how performance among various types of students informed their support. Principal 6 stated:

> Here's one in which I was able to aggregate the data as well. So, we can start to see some patterns. So, this is [school year] 15–16 and looking at our achievement for all students. So, 345 students in testing grades and then for the ones that met proficiency. This is for language arts, and it is combined language arts and math. What's the percentage of our population? What is the percentage that are receiving free-reduced lunch? How many of

them are receiving special education? And then looking over time, nonhigh needs versus high needs in terms of how are they scoring. And that's coming from just the raw data that we have here. And then pulling the data from the individual sheets.

In order to make comparisons among programs on campus, such as various academy pathways, Principal 4 described using the Longitudinal Data System to form cohort groups, a function that enables schools to track groups of students based their own criteria. The cohort feature was described as a tool that empowered schools to look at metrics together, for example, demographic and process data. He said, "We do use some LDS data in our academies to track attendance, to look for our students within our cohorts, and within our academies that need intervention" (Principal 4). Upon further explanation, the principal said that the academy leads created the cohorts of students in the LDS system, and they checked it and maintained it as students moved in and out of programs. The support the principal received from the division of labor made it possible to maintain school-level data analysis that compared programs.

In conclusion, digital data tools supported users in comparing data sets over time, among schools, and within schools in ways that provided a context for related data points. Comparison of data naturally led principals to the next action—using data for planning.

Use of data for planning. All interviewees talked about how they used data and a variety of tools in their school-wide planning processes. They described using data mainly to inform goal setting, academic planning, staffing decisions, and planning supports for teachers. In the following statement, multiple tools and data sources were used to triangulate information and make plans that involved a grant for professional development with Stanford Professor Jo Boaler:

> Like, for example, that when we do our academic plan, we always precede that with a comprehensive need assessment. So, for example, one of the areas in which we're looking at is math. So, what does our data show us in terms of a walkthrough, in terms of what we're seeing on SBA [Smarter Balanced Assessment], in terms of what we're seeing in our universal screeners, how are we progressing in math? Where are the areas of weakness for the kids? And yet that's part of the reason why we were. That's a large part of the reason why we applied for the grant with Jo Boaler, knowing that number sense is this issue K–6. And we see that.
>
> In terms of the perceptual data that we hear from teachers, we see that in terms of the universal screeners, kids not being able to problem solve. And when we drill down, it's because of the lack of number sense we're seeing in SBA. As that gap continues to grow between the kids that are on free and reduced lunch versus the kids that are not and those who receive special education services and those who are not. So, we're seeing it in multiple venues, and we're using the sources of data that we have in order to triangulate and verifying. I think if we just depended on SBA that wouldn't be enough, you know, nor would it tell us more specifically where the kids are. (Principal 6)

Proceeding beyond looking at standardized test scores was important in that comprehensive need assessment process. In order to move beyond demographic data and key performance indicators, perceptual data and other data sources were needed in order to identify true needs. An additional example was provided by another principal, who discussed examining data in order to plan teacher support:

> It affects how we do professional development. We look at—when I look at that data, I see that maybe it's not I ... it's not really an "I won't," but maybe they just "don't know." So, what we've done is—we've kind of looked at the data, and we dug down real deep. And we said that we drew a conclusion, that they probably don't understand the standards deep enough to do the things that we're asking them because they can link the standards, but they don't understand it deep enough to really have that ability to let the kids decide where to go in a lesson or to differentiate or to make accommodations when they write the lessons. When we—part of our data collection is we collect lesson plans—we can see how rigid it is and how shallow the unpacking of the standards is. So the change of professional development, too, you know actually go backwards. And go back and start to revisit and teach them how to unpack standards that we use the data to determine that. (Principal 4)

In addition to school-wide academic plans and staff development plans, principals were also responsible for financial planning. At least half the interviewees mentioned using the Office of Human Resources tools to look at the projected enrollment numbers and determine the number of staff members that they would include in their budgets. Principal 1 used the word *obvious* when talking about using data for this type of planning: "OHR portal right? EHR/OHR whichever way. I don't know … but I use that all the time obviously in the school list and hiring and financial plan." This is an annual reality. She continued, "Every year I'm letting go teachers. It's been two. This year was only one, … so you have to make staffing decisions based on the data" (Principal 2). In summary, plans were informed by past data, current data, and projected data. While engaging in continuous school improvement, the cadence of the plan–do–check–act

cycle meant that schools were always in a state of planning while simultaneously responsible for periodically reporting on progress.

Use of data for reporting. The basic definition of *reporting* involves sharing information. In this study, the use of data and digital data tools for reporting entailed both gathering reports and generating reports. The types of reports ranged from formal to informal reports for both internal and external audiences. Formal reports like the public Strive HI report, shared with external entities, were often linked to the state and federal accountability systems designed to determine whether schools have met annual standards or required additional supports. The Hawai‘i Department of Education is responsible for generating annual accountability reports for intended audiences: the general public, the HIDOE employees, and the U.S. Department of Education. Although the data may be the same, the reporting tools and formatting are unique to each audience. Formal Strive HI accountability reports are made available to the public in PDF format by individual schools and a master Excel file on the department's website and the Accountability Resource Center Hawai‘i website. Principals can also log in for additional access on the interactive Accountability Data Center tab as part of the ARCH ADC database, which provides data visualizations on student metrics for public schools in Hawai‘i. Principals can download the underlying student data that officially counted in the annual accountability data and check it before the synthesis is publicly released. The comments that emerged from the interview data conveyed limited familiarity with and use of these reporting tools. One principal said:

> I think when we're writing reports and doing WASC and academic plan and things like that, then we get into—oftentimes we get into—out of old habit, the SSI and the ARCH

website place although I think sometimes that's duplicitous [duplicative]—so whatever word that is—to what other things maybe LDS has. But that's the place we go. So like when I'm looking for information around writing for the SSIR for my next year, I go back in here. I mean, this is the one that I think I go to a lot. It's the accountability resource center. Even though some of the data is not as up to date as maybe some other sources, … I think under ARCH that it's mostly the data trend report and the SSIR. Under the district's website, the DOE one was like the school profile and those things. Now I go there to get all my reports like past SBA or if somebody wants. That's where I sent people to get their information. So—but again, you know, I don't use it except for when I need something. Yeah, and I think that, but I think we also—I think it would be nice if I was—if I was trained in a routine of maybe how to make it a part of a habit. (Principal 1)

The concerns about the timeliness of data and whether or not one data source repeated data from other sources were compounded by the irregularity of use and lack of training. Another principal was observed struggling to locate his report:

So, this is the ARCH database. This is supposedly supposed to give me my Strive HI scores, but it's not giving it to me. And that's the only place I can get my actual Strive HI in there, and it's embargoed until the public gets to see them, right? So this is another database that's separate than all the other ones that we have to use as well. (Principal 5)

During the observation and think-aloud, the researcher noted that although the tool empowered principals to access underlying student data, most principals were not observed using

those detailed features because they mainly accessed trend reports or experienced challenges when trying to access their data.

In addition to their position on the receiving end of formal reports like the Strive HI accountability report, principals also played a key role in generating formal reports, such as the Western Association of Schools and Colleges (WASC) accreditation report, reviewed in six-year cycles with midterm visits based on need. The process of collectively generating a report created a focus on data use among school faculty and stakeholders. A principal said:

> I think the WASC (process) is real good. This whole process to focus on them—it's good for them. They don't see it that way, but I'm sure I know my focus group leaders see it. They see the benefit from this. (Principal 2)

All public schools in Hawai‘i are expected to go through the WASC accreditation process. Three of the four principals interviewed stated that they had set up their own Google Suite tools because the HIDOE would not officially support Google tools until spring 2019. The collaborative functions on the Google Suite were crucial for this work. Principal 5 stated:

> Google—when we had our Western Association of Schools and Colleges—everything was there, so when they came through and they wanted any information, we linked our academic and financial plan, our comprehensive needs assessment, all of the lesson planning.

Google tools clearly emerged as the most versatile and popular tool for both formal reports like WASC as well as informal reporting.

Principals shared the manner in which information flowed up to them, flowed collaboratively among groups, and could be used to disseminate the information they wanted to

send out. The following statement shows that school leads shared information about progress with the principal weekly:

> I'll contact my academy leads every week to say, "Where are our kids? Where are our hotspots? What are we doing?" We use the Google and everything and LDS to kind of track everything and keep tabs. LDS is our back up. You know, I can hopefully—we can see some improvement in it as we go from point A to point B. (Principal 4)

Google was a popular tool for internal reporting and housing a variety of types of data digitally. Principals viewed these tools as a way to remain informed. One said:

> So, this is everything that we've got. So, I can go in here, and I can get everything we've got. I also do our, uh ... leadership meetings on this one. … I've got all the agendas on here, too. We have to go back and check out what we're doing. Any "shared with me" documents that are coming through—for instance, we've got WASC and other folders. Everything that I can, we save on these; and then I can just pull it up. So, we use Google for anything that we've got. Even our [name redacted] database—that's our alternative educational placement for drugs, alcohol, alternatives to violence. … So, I can pull that up and see what our attendance is, our grades are, what's the correspondence back and forth between the teachers. That type of stuff, you know, so we use the Google platform a lot. And it's an instant reference to certain things that we need to have. (Principal 5)

In contrast, another principal admitted that the information flow was more consistent among members of a select leadership group on campus but underused in conversations with the larger staff. Despite using a principal's blog for reporting data, this principal believed that information flow was an area for growth. He said:

> My greatest weakness is sharing the data. I look at it all the time. I show our VPs pretty consistently. We look at it as a leadership team. Okay, I summarize the data and put it into my blog directly for staff. I do this weekly. See? Can see like here. I always talk about stuff up here like just a general—like here is where we are—but we don't talk about it. (Principal 3)

Digital tools are far from having been universally adopted. In another example of sharing data with staff members, a principal said, "We usually will do a PDF that they can access on Drive, but most of them love the hard copy; so, we print it out as well" (Principal 6). In summary, the variety of tools used in schools still ranges from traditional paper and pencil to modern digital tools. Principals are using what they have access to, sometimes creating their own systems in house so that they can engage in comparing, planning, and reporting data.

Comparison of Quantitative and Qualitative Results for RQ2

The primary source of data to answer RQ2 derived from qualitative data collected through open-ended questions posed to participants. The rich descriptions gained from the interviewees clarified and expanded upon the data use list that appeared in the Data Use for School Development scale used in the survey. Survey results showed that nearly every principal used student results to determine yearly goals for school improvement, which was confirmed by the interviewees who provided specific examples of how they compared types of students across time intervals, schools, teachers, subgroups, and programs. Although the survey provided an overview that roughly 67% of principals used external evaluations for their own improvements, the interviewees themselves provided the rich descriptions about how they used reports like those associated with WASC accreditation in their improvement process. The indicators from the

survey that generated relatively lower responses, such as using results of students to evaluate teachers and design instructional time based on student learning needs, were never mentioned by interviewees, confirming that these were not common uses of data. Overall, the two phases and methodologies for data collection complemented each other well and were instrumental in uncovering themes surrounding data use and data analysis tools for comparing, planning, and reporting to seek insight.

Research Question 3: Factors Influencing Use of Data Analytic Tools

For the third research question about factors influencing use of data analytic tools, quantitative data were obtained from four scales: (a) Data Characteristics Scale, (b) User Characteristics Scale, (c) School Organization Characteristics Scale, and (d) Computer Systems Characteristics Scale. The first three scales were used with permission and adapted from Schildkamp's Factors Affecting Data Use Survey (personal communication, October 26, 2017), and the fourth was used with permission and adapted from the Teacher Data Use Survey: Administrator Version (Wayman et al., 2016). A Likert scale was used to quantify the agreement of principals with each statement: 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral*), 4 (*agree*), and 5 (*strongly agree*). Data collected from the think-aloud and semistructured interviews contriubted additional insight and depth to the findings from the survey results.

Quantitative Results for RQ3

In this section the four scales from the survey are described and then compared to determine the factors principals found most influenced their data use.

User characteristics. The User Characteristics Scale consisted of eight items based on the notion that the knowledge, skills, and dispositions of users are important factors in data use.

As shown in Table 8, all items had mean values over 4.0, indicating agreement with all items.

Table 8. *User Characteristics Scale (N=70)*

	Disagree = 2	Neutral = 3	Agree = 4	Strongly Agree = 5	Mean	Std. dev
Students benefit when instruction is based on data.		4.5%	46.3%	49.3%	4.45	0.58
It is important to use data in determining individual student needs.		1.5%	54.4%	44.1%	4.43	0.53
Data are important in changing my practice.		4.4%	52.9%	42.6%	4.38	0.57
I am comfortable in interpreting data that are presented in graphs.		7.4%	67.6%	25.0%	4.18	0.54
I know how to interpret the data and the reports I receive (exam results, student achievement results of previous years)		10.3%	66.2%	23.5%	4.13	0.57
I am able to adjust my practice based on data.		8.8%	70.6%	20.6%	4.12	0.53
I am able to use data to diagnose student-learning needs.	2.9%	2.9%	76.5%	17.6%	4.09	0.57
I understand the quality criteria and concepts for data use (e.g., correlation, validity, reliability).	4.5%	9.0%	65.7%	20.9%	4.03	0.70

More than 95% of principals agreed (rated 4 or 5) with all three items involving the benefits or importance of data use, indicating they believed students benefit when instruction is based on data (95.6%), that data is important in determining individual student needs (98.5%), and that data is important in changing their own practice (95.5%).

The remaining five items assessed the principals' confidence in their own ability to use data. For three of these five, 90% or more of the principals appeared to perceive themselves as competent users (rating of 4 or 5). These included feeling comfortable interpreting the data

presented in graphs (92.6%), adjusting their practice based on data (91.2%), and using data to diagnose student learning (94.1%). They were slightly less confident in knowing how to interpret data and reports they received (89.7%) and understanding quality criteria and concepts for data use (86.6%). The User Characteristics Scale was the only scale that generated no responses of 1 (*strongly disagree*) and few responses of 2 (*disagree*), another confirmation of principals' overall belief in the importance of data use and their confidence in using data.

Computer system characteristics. Following User Characteristics, the next most positive responses were generated by the five items from the Computer System Characteristics Scale. Table 9 shows that two of the five items yielded means above 4.0 and the remaining three, above 3.5, indicating general agreement that the district's computer systems met their needs.

Table 9. *Computer System Characteristics Scale (N=70)*

	Strongly disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly agree = 5	Mean	Std. deviation
I have the proper technology to efficiently examine data.	1.5%	1.5%	7.4%	51.5%	38.2%	4.24	0.77
The computer systems in my district provide me access to lots of data.	2.9%	1.5%	7.4%	52.9%	35.3%	4.16	0.86
The computer systems in my district allow me to examine various types of data simultaneously (e.g., attendance, achievement, demographics).	2.9%	11.8%	10.3%	52.9%	22.1%	3.79	1.02
The computer systems in my district generate displays (e.g. reports, graphs, tables) that are useful to me.	2.9%	8.8%	20.6%	54.4%	13.2%	3.66	0.92
The computer systems (for data use) in my district are easy to use.	2.9%	13.2%	22.1%	44.1%	17.6%	3.60	1.02

More than 75% of the principals agreed or strongly agreed (rated 4 or 5) that they had the proper technology to examine data efficiently (89.7%) as well as access to plentiful data (88.2%) and systems that allowed them to examine various types of data simultaneously (75%). More than 30% of principals expressed less than satisfaction (rating of 1, 2, or 3) with the usefulness of

computer systems' displays for items like reports, graphs, and tables (32.3%) and ease of use (38.2%) of computer systems meant to support data use.

School organizational characteristics. Organizational characteristics that included vision, leadership, and support related to data use were measured by 16 items on the School Organization Characteristics Scale. As shown in Table 10, this scale generated a trend of positive agreement in responses but with greater variation than the previous two scales. Not a single principal disagreed that they were strongly encouraged by the district to use data as a tool to support effective practice. Principals responded to the top three statements with high agreement (rating of 4 or 5), indicating a shared awareness of the need to develop data analysis skills (96%) and consistent encouragement from leadership to use data. The majority of principals agreed or strongly agreed to the next 12 statements describing various organizational characteristics, such as using a structured method to analyze and interpret data on which to base actions (75%), feeling adequately supported in the effective use of data (71%), and having a supervisor who discussed data with them (61%), to name a few. Notable for the focus of this study, only slightly more than half the principals (52%) agreed that someone helped them change their practice based on data. Less than half agreed or strongly agreed that a specific time was set aside for data use (44.9%).

Data characteristics. The Data Characteristics Scale consisted of 10 items measuring principals' perceptions of data quality, such as access to timely, relevant, and accurate data. This scale had the lowest overall mean of the four scales on the survey ($M = 3.33$) and the most variation in responses as shown in Table 11. Most principals agreed or strongly agreed (rating of 4 or 5) that they had access to relevant student data (85.5%), which tracked progress (81.6%) and

Table 10. *School Organizational Characteristics Scale (N =70)*

	Strongly Disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly Agree = 5	Mean	Std. deviation
My school is aware that we need to keep developing the skills of teachers to analyze data.			4.4%	63.2%	32.4%	4.28	0.54
Our district encourages data use as a tool to support effective teaching.			10.1%	60.9%	29.0%	4.19	0.60
My supervisor encourages data use as a tool to support effective practice.	1.4%		13.0%	62.3%	23.2%	4.06	0.70
In my school we use a structured method to analyze and interpret data to base actions on.	1.5%	5.9%	17.6%	58.8%	16.2%	3.82	0.83
Data use is a priority in my school.	1.4%	10.1%	17.4%	52.2%	18.8%	3.77	0.93
There is someone who answers my questions about using data.	1.4%	7.2%	24.6%	47.8%	18.8%	3.75	0.90
I am adequately supported in the effective use of data.	1.4%	7.2%	20.3%	58.0%	13.0%	3.74	0.83
Teachers in my school share a common understanding about what good teaching is.	1.4%	10.1%	15.9%	63.8%	8.7%	3.68	0.83
My supervisor creates many opportunities (e.g. time) for me to use data.	1.4%	4.3%	34.8%	44.9%	14.5%	3.67	0.83
My supervisor is a good example of an effective data user.	2.9%	5.8%	36.2%	37.7%	17.4%	3.61	0.94
Teachers in my school share a common understanding of what student learning is.	1.5%	13.4%	14.9%	64.2%	6.0%	3.60	0.85
My supervisor discusses data with me.	1.4%	8.7%	29.0%	50.7%	10.1%	3.59	0.85
My supervisor discusses the results of their data analyses.	1.5%	7.4%	35.3%	45.6%	10.3%	3.56	0.84
There is someone who helps me change my practice based on data.	1.5%	13.4%	32.8%	41.8%	10.4%	3.46	0.91
Teachers in my school share a common understanding about effective ways to evaluate student learning.	2.9%	23.5%	20.6%	47.1%	5.9%	3.29	0.99
There is specific time set aside for me to use data.	2.9%	23.2%	29.0%	43.5%	1.4%	3.17	0.91

Table 11. Data Characteristics Scale (N=70)

	Strongly disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly agree = 5	Mean	Std. deviation
I have access to relevant data on my students.	1.4%	7.2%	5.8%	66.7%	18.8%	3.94	0.82
I have data on the progress of my students.	1.5%	9.2%	7.7%	70.8%	10.8%	3.80	0.81
The data to which I have access to help me plan my support.	1.4%	7.2%	14.5%	63.8%	13.0%	3.80	0.81
With the data I have on my students, I can determine the growth of my students from year to year.	4.3%	10.0%	12.9%	65.7%	7.1%	3.61	0.92
The data I have on my students are up to date.	1.4%	8.7%	26.1%	58.0%	5.8%	3.58	0.79
The data I have on my students are accurate.	2.9%	5.7%	31.4%	54.3%	5.7%	3.54	0.81
Data on my current students are available at the beginning of each school year (within 3 weeks).	1.4%	18.6%	15.7%	58.6%	5.7%	3.49	0.91
When students start in the middle of the school year, their data becomes quickly available.	1.4%	26.1%	36.2%	34.8%	1.4%	3.09	0.85
I can find all the data on my students in one system.	17.1%	50.0%	14.3%	18.6%		2.34	0.98
I have too little data on my students.	18.8%	52.2%	21.7%	5.8%	1.4%	2.19	0.86

was helpful in planning support (76.8%). Agreement surrounding descriptors of data accuracy (60%) and timeliness (63.8%) was slightly less with a third responding neutral (rating of 3) or disagreeing (rating of 1 or 2). When asked whether data was available within 3 weeks of the beginning of a school year, 20% disagreed and more when students started midyear (27.5%). The majority of principals disagreed (rating 1 or 2) that they could find all the data in one system (67%).

Overall factor means. Of all the factors affecting data use, principals rated their own user characteristics most favorably ($M = 4.23$). The overall perception of computer system characteristics ($M = 3.89$) and school organizational characteristics ($M = 3.70$) were in the

middle with the data characteristics perceived as the most lacking ($M = 3.33$) as shown in Figure 19.

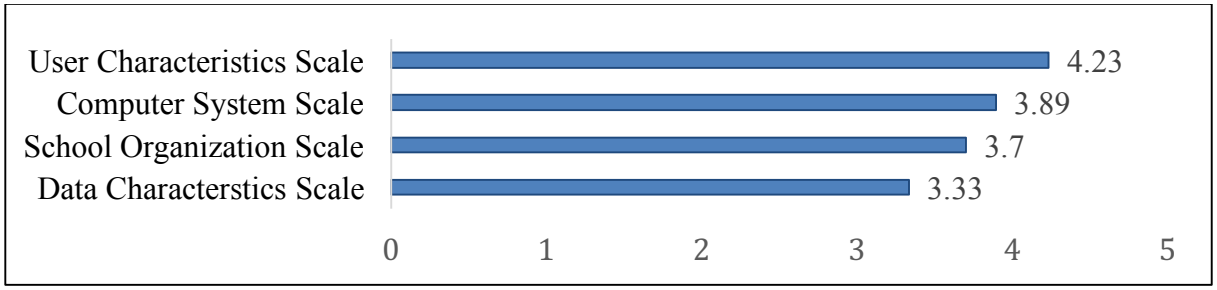

Figure 19. Comparison of means for factors affecting data use subscales (N=70).

Qualitative Results for RQ3

The qualitative data generated in Phase 2 confirmed many of the findings surrounding the factors influencing data use. Organized under the themes of computer system characteristics, data characteristics, school organizational characteristics, and user characteristics, the additional trends and categories that emerged appear in the following sections. A summary of the factors influencing data use found in the qualitative data appear in Figure 20.

Computer systems characteristics. During the think-aloud, observation, and interviews common factors that emerged from experiences with various systems were categorized into accessibility, integration between systems, functionality, and user-interface issues. These factors appear in visual form in Figure 21 in relation to the other themes.

Accessibility. The term *accessibility* is often used in relation to assuring that products are accessible and usable by people with a range of abilities; however, the type of evidence categorized under accessibility in this study dealt with the most basic form of acquiring access as

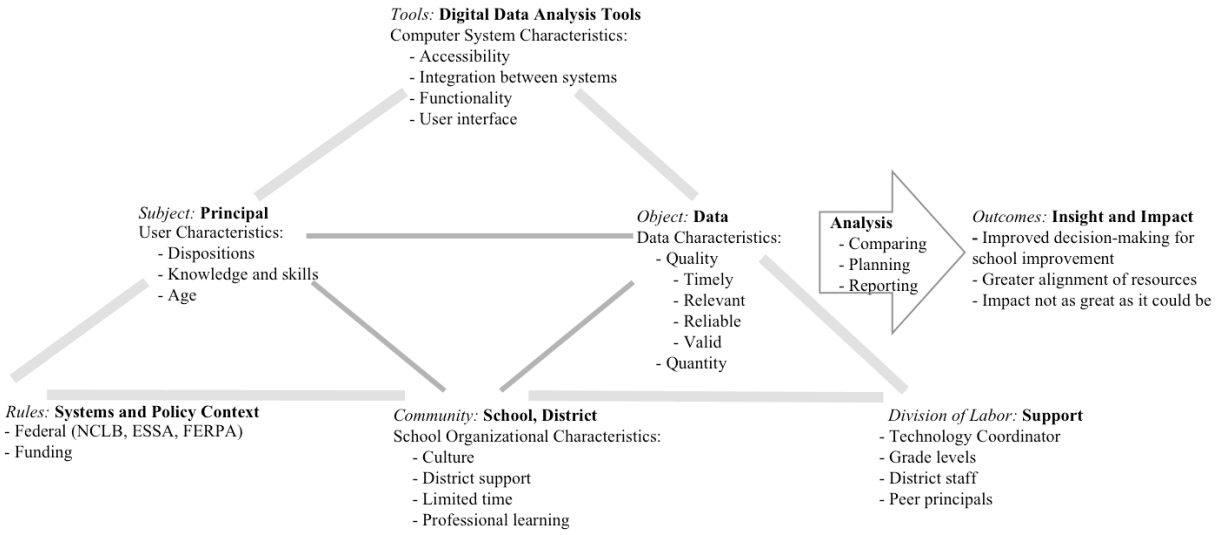

Figure 20. Factors influencing use situated in the conceptual framework.

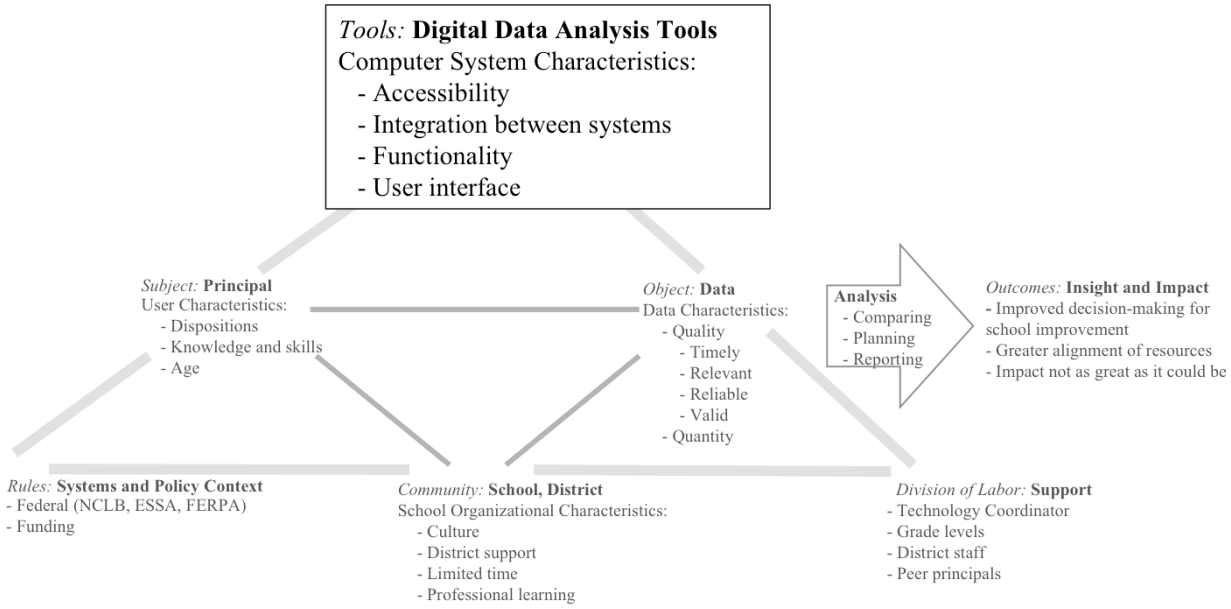

Figure 21. Categories of computer systems characteristics.

it was affected by login issues, password changes, and privacy limits. Principals expressed confusion in that "systems change frequently, including access protocols and formatting, so it's difficult to keep up" (Open-Ended Survey Respondent 35). During the think-aloud sessions,

several participants were observed struggling with login challenges, ranging from a few seconds to several minutes. One attributed it to his own error: “Yeah, I mean, okay. Oh, boy! What was my log in? I forgot already” (Principal 3).

Speculating that the accessibility issues might be system-wide, Principal 5 said:

> Um, this one’s not coming up for whatever reason. That’s my Infinite Campus login. ... Let me try this again. ... Ah, here we go. ... No. ... Why is this kicking me out? Oh, okay. Gotcha. Okay. ... Oh. ... Let’s see. ... It usually signs me on. ... It usually signs me on. ... This is my memory? Or I know sometimes the sites update passwords every year or something. Well, they make us do it on this. OK, here we go. Okay. That’s why. It did change. ... See? Here it’s making me say I gotta change it. Yeah, let me try iPhone. Let me try that. ... Why isn’t it letting me on? Let’s see if this is it. ... Is that the single sign on? Is supposed to be. It’s like some of the things that are on it. No, this one, though, doesn’t do the single sign on. You have to ... Yeah, K12.hi. ... Wow. That’s frustrating. Well, maybe this thing. Copy this. Okay. Oh, man, this is frustrating. I’ve got the right password. It should let me in. Um ... and ‘cause this—the DOE one, so. ... Oh, man. ... Well, you know, for whatever reason it’s not letting me in. I don’t know why that would happen. I should be able to get on. It shouldn’t be locking me out like that. … Let’s see eCSSS… [trying to log in]. ... Don’t tell me they’re revamping everything.

The word *frustrating* summarizes the experience of principals encountering accessibility issues. They are charged with leading and managing schools, so when facing limited access to educationally relevant data became another point of frustration. For example, one principal pointed out that “administrators should be able to track their students from K–12 instead of the

current access to only school level" (Open-Ended Survey Respondent 21). Frustration with lack of access was also viewed by principals as a barrier to teachers who are limited to seeing only student data for those currently in their class instead of incoming or outgoing students. One stated:

> I would think it would be Infinite Campus, but we don't—they [teachers] don't normally have access. So, they would have access to their own children for this year's report card, but they don't have access in my understanding of previous years so that our clerk registrar would have to print out reports. So, say if I want to come in and find about—can I see the report cards for my 20 or I go into all of their cumulative folders and pull all those cums [cumulative folders] and look at them. So, to me that would be another piece. I don't know what people in a different job think about the idea that you're going to do. You have the right to see what the kindergarten, first-grade, second-grade, third-grade teacher wrote in the report card. Well, it seems like if you go into in the cum[ulative] folder, that if it was in a system and you could have access to it, right, then you could just electronically. (Principal 1)

Given the federal FERPA regulations, the district interpreted and applied those policies in a way that resembled a barrier. In the example above, the principal described the way teachers in his own school had been blocked from digitally accessing data for students they had taught during the previous year. In another example, a principal described how restricted access due to privacy concerns from the state office could also prevent interaction with data more efficiently, using tools in a new way:

> We have been trying to get HIDOE to allow us to cull the data thru Google, but they keep telling us they can't allow student data over the Internet! This means that my teachers have to cull the data off all of their sites and make a spreadsheet where they would have to enter the data rather than just culling the data thru a company like Illuminate, who can do all that. ... They do it for other states ... but not us. ... Our teachers have to do all that by hand. (Open-Ended Survey Respondent 32)

In summary, accessibility to data through digital tools remains a barrier for some principals.

Integration between systems. Integrated platforms combine several applications or tools into one single convenient access point. The HIDOE has integrated data primarily through the Longitudinal Data System, which typically syncs with a number of other systems overnight. Principals acknowledged the improvement over time. One stated, "There is no one-stop shop although LDS is much better than it once was" (Open-Ended Survey Respondent 26). Despite the progress that principals have seen, many still hoped for additional integration, and several made comments along the following lines: "I would like one system that has everything in it. Right now I have to access like 10 programs (Infinite, eCSSS, STAR, ARCH…)" (Open-Ended Survey Respondent 47). When asked, "If you woke up tomorrow and all your challenges had been solved, what do you think would be different?"—more than one principal talked about a desire for integration. Principal 3 stated the following:

> You know, I feel—just like an organized like place. You know? If somehow there were ways that I could personalize the things that I wanted to see—so instead of having to go into eCSSS to find this particular thing, I'll just say, This is what I want to see on my own page. You know, like my own home page. Yeah, if it were like the iReady—if I

> could have the iReady data as soon as it's coming out. It just goes to the home page. So instead of me logging into all of these different things, it's literally like right on one page, and it's constantly changing as we move along, ... a personal dashboard with the things that I want to see.

Not only do principals envision more one-stop shopping, but they also envision more actively shaping the experience for what is meaningful to them. If it is meaningful to them to disaggregate data by programs that are unique to their individual context, they want that process to be smooth and efficient. One stated:

> The data is available but is not accessible in the most efficient way—too many different data sources—would like it to be in ONE place. I would like to see a full student profile with attendance, behaviors, course grades, RenLearning [universal screener], Achieve [reading program], Panorama [student survey], et cetera. I would like to generate statements, such as "Of the ____ students who were in the reading workshop class for both 6th and 7th grade, _____ demonstrated a typical or greater growth score on the SBA Language Arts at the end of SY____." This is useful information for our Comprehensive Needs Assessment as we are using data to determine the efficacy or impact of our reading and math workshop courses. (Open-Ended Survey Respondent 27)

Without integration, filtering and disaggregating are challenging because the demographic data in one system might not be linked to performance data in another. Logging into multiple systems can be time-consuming, and principals expressed a desire to repurpose the time that they spend on the technical side. For example, "I need to have access to profile data

that go beyond demographics, so less time is spent compiling the data and more time is spent providing the supports for staff and students" (Open-Ended Survey Respondent 27).

Exemplifying a lack of integration, a principal described how they typed the same information into two different systems to track referral incidents because one was used internally at his school and the other was reported to the state; the two systems don't talk to each other. In the quotation that follows, the letters A, B, C, and D refer to the level of referral offense, and the two systems into which they input data were eCSSS and IBM Lotus Notes, which allowed the school to create an electronic form and database to track their referrals internally. The two systems were both supported by the HIDOE but were not integrated. One principal stated:

> So, ours is an online referral system. So, if they have an A, B, C, or D referral that they're going to give to us, we will get A and B usually sent right to us. And it goes through Lotus, not eCSSS. It goes into eCSSS after we've done our process through our referral system that we input. We have to input in eCSSS. It doesn't read our referral database because this isn't the same as what eCSSS does, and they don't have permission to talk. It pretty much is a double input because they're inputting it in our referral database, and then once we've handled it and done everything, if it's a C and D referral, we have a clerk that we've hired to input because it's just—everything is on that. If it's an A and B, we as an administration have to input, so it is a double. The teachers have to put it in; we pull it up. We enter into this [Lotus database]. See, one again, it's not letting me ... probably because it's on guest network. ... Let me use my phone [unable to pull up the database]. We have to input it. Then after we've done it or the clerk does after we're done

> [with] the referral. We designed it because the paper one isn't as efficient as this one. And we do both negative and positive referrals. (Principal 5)

The lack of integration of these two systems meant the school had to hire a clerk to type referral information into eCSSS that had already been typed by teachers in the Lotus Notes database. Although the principal acknowledged that this was more efficient than the paper system they previously used, the underlying sentiment of his story was consistent with others who still desired a better solution.

When asked what would help to solve current data challenges, another principal responded, "We probably would have either hired a guy to write a database for us … or found a really great vendor who has it all in one solution" (Principal 6).

A third dreamed of having access to an integrated platform with artificial intelligence that responded through natural language processing:

> Well, in the dream world it would be like—and maybe we can name her Alex. Alex, I need all of the information about little Johnny, and then Alex on my computer pulls up everything we have about little Johnny. And it's all in one spot, and that was as complicated as it was for me. Alex, compare Smarter Balanced scores for the last 20 years or whatever it is, and create a graph for me that shows or whatever you do … analysis of SES background, demographics of the students who are nonproficient, and it will be [snaps fingers] like that. I can already do that around songs and stuff that I want. (Principal 1)

The idea that tools should be naturally intuitive and do more for people than they currently did also reinforced the next theme—functionality.

Functionality. The functionality of a system entails the range of operations of which the system is capable. In addition to the lack of integration of systems, participants made several comments about how systems did not have the desired functionality for a school's unique context. As a result, principals often expressed a desire to continue looking for better solutions. Principal 6 stated:

> We're trying to find a database system that can keep better track of the various types of data that we have like Benchmark Assessment System, Math Perspectives, so [an] all-in-one component where we can produce STAR-like charts and so we can see the progress over time. But we haven't gone there yet.

Principal 1 also thought the LDS would have more functionality than it does. He stated the following:

> If we could ever get to that level, right? Where that K–12 was that a teacher doesn't have to be the one to—you know, I mean like every year redo that. … So, all the grade levels create pink and blue forms, and I don't know what they are called at other schools in which teachers collect data or share data about the classes we've created for next year's teachers, elementary teachers. So, like here's what their STARs were, here's what their dadada. … This one has, you know, challenges around, you know, someone needs to sit. ... It's better. He's closer than the teacher. So, in a sense they're doing that for all the kids, right? And then they're passing that data forward, but then there were concerns, right? Do we, you know—and we in the past—we've shredded all that because are we violating—are we prejudging or? ... And I don't know where we are with that, and in some ways that's why I thought LDS was going to be that—LDS would be much more

> filled with—boy, there's so much on campus. I can see from kindergarten on what teachers said strengths were, teachers said weaknesses. ... Wow, in third grade. ... That change in a sense, almost a glorified electronic cum[ulative] folder. Right? And then I could track all that, and I could pull up your math performance from in ninth grade. I can say, "Wow, sixth grade! She was right on target and then something happened that she dropped." But then I can look in there, and also that that correlates to what I was reading about. That's when her mom and dad went through a divorce. And I can see all this, and so I'm getting all this information and knowledge so that when I, you, walk into the principal's office, it's not cold. I have a much better picture of you. Right? Or you walk into RTI, or you walk into a teacher's classroom, and that teacher goes, "I am not saying I know you, but I have this detailed picture." So, I think that's helpful. … So, I think one of the things would be questions around do we eventually make this into something we do electronically?

Tension exists between what principals hope to do with a system and the functionality available to them. More than one principal shared their desire to have data relevant to their unique context for tracking interventions or other valuable data points in response to the following question: Do the digital data tools you use to access data do what you want them to do? For example, Principal 6 answered as follows:

> Not completely. They do a lot and we're thankful for them because they are useful, and we do use them frequently. But as I mentioned before, we are searching for a better database system. There was one called RTIM that we were going to test out, but I just couldn't make it work with Clever. It was more keeping track of progress monitoring,

> keeping track of interventions, the frequency, the intensity, you know, keeping all of that, housing of all of that information in one. And it is just kind of like ESIS but for RTI. Right now, we are just using a spreadsheet, and it's clunky.

Many of the database systems sponsored by the district were standardized across the entire state as opposed to allowing school-level users to input data or customize aspects unique to the school context. RTI is an acronym for Response to Intervention, a strategy that varied by school. The subject of the absence of a district-supported tool with the functionality to monitor RTI arose multiple times as a need area. Principal 4 stated:

> We do use some LDS data in our academies to track attendance, to look for our students within our cohorts, and with the—in our academies that need intervention, different intervention levels. But still that really doesn't drill down to the types of interventions we need to give kids to stay current. So, we've been having to create our own intervention as far as putting it on a platform and having it electronically done. We're not at that point yet. … That's what we're figuring out. … It's all going to be by hand right now.

The same principal stated that his counselors interviewed chronically absent students to find out why they were absent from school, but they had no tool with the functionality to capture or analyze that data. Principal 4 recounted the experience: "Each academy has a counselor, and they just collected it by hand. There's no easy way to input it yet. There is no program that can collect all of that type of anecdotal data and then put it out." In addition to collecting perceptual data from students using a paper-and-pencil system, personnel at this school did so for their classroom walkthrough data as well while they sought a digital solution.

In summary, the functionality of existing data platforms, designed to enable principals to view, download, and filter data as consumers of that information, has left them wanting. In addition to wanting more integration in the functionality as noted above, principals also wanted to be able to input school-level data based on their own program needs and data types. They stated that having multiple platforms was not always as helpful as they wanted because some systems seemed to repeat the same functions already available in other systems, such as looking at the same annual standardized test results.

User interface. User interface refers to all aspects of a product design with which a person may interact. In their own words, some principals made comments like "eCSSS is not user friendly" (Open-Ended Survey Respondent 68), and at other times during the observation and think-alouds, users mentioned encountering common challenges. Factors under the user-interface category that impacted principals' use of data analytic tools can be categorized as navigational challenges, formatting issues, and loading times, all of which seemed to slow principals down or leave them feeling confused. A survey respondent commented, "I have a difficult time following the district's thinking when they set systems up—different point of view [or] paradigm" (Open-ended Survey Respondent 45).

Another principal suggested a directory to help address the navigational challenges they faced:

> If a directory tool were created, indicating what system to look at for certain information, that would help us navigate through all the tools easier and save us time. This would be especially helpful to those of us who don't regularly access all the databases. This will result in increasing our productivity. (Open-Ended Survey Respondent 19)

During a 10-minute segment in the following portion of the think-aloud, Principal 2 struggled to click through various filters and troubleshoot on LDS while trying to pull up a report unsuccessfully. She said:

> Hmmmm, there's no search. I can't even find mine. I'm not used to this. Hahaha. So from here I don't even use any of this stuff over here. I don't even go to the ELL access. All I do is I look for the—you know, like unless I have to do achievement. So it, hmmm, takes a long time to load, huh? Student test results—take a look at the ELL, 17–18. K, name of school, name of test ... HSA. Um, no, no. I don't see that. SBA. My God ... [laughing] ... Grade on, gender on, EL Migrant on. OK, report. I don't know why it's not showing 17–18 test years. Staff all. ELL all. SPED all. Let's check. Oh, I have to click on the grade on the bottom. Let's click on third grade. It's the third grade. Gender all, okay. Migrant, no. Low SES all. Staff all. Isn't that strange? I'm just going to get out of this school, K. Let's see if this works. … Still loading. Ahhh, hmmmm. Come on, "Test score results in this report are unofficial test scores and should only be used for informational purposes," but I'm not even getting the test scores. That's really weird. OK, let me—let me see. Maybe it's not working. Yeah, it would be nice if they could say on there or hide it until works—that way since that is confusing. It's stuck, maybe it's stuck. … Currently enrolled students, profile reports, school report. ... I mean, if I use it, it's just the beginning of the school year. Yeah. Yeah. And then usually we just do the, um, our formative.

During this interlude Principal 2 was observed trying numerous clicks and resetting the same filters over and over to try to run the report again. The filters appeared not to have been defaulted

to this specific user's school information. When the attempts were unsuccessful, the system did not provide an error message with feedback on what should be changed. Observing what functionalities the user expected to view (e.g., a search tool) but could not find was beneficial.

Multiple principals also struggled to navigate and find things when using Google Drive as illustrated by Principal 3:

> Where did my walkthroughs go? ... Well, I'm feeling quite rusty right now. … Where did I put my walkthrough data. ... Okay, hold on. I can't remember what folder I have it in. ... Here's one form, … Classroom Walkthrough 2. ... Okay, it's not in there. I'm looking up. …Where in the world did I put that? Where did I put that? It's a walkthrough form.

Google provides users with a search tool, but it's possible that they have become over reliant on that search feature and still struggle to locate documents, a challenge that marked a trend. Principal 4 elaborated:

> That's my biggest downfall right now. I cannot find things, trying to find, say, minutes from an academy meeting for hospitality that happened in May. ... It's a hard search sometimes, right? Depends on where it's posted. So yes, I have like certain folders and naming conventions, ... and we haven't really gotten good at that yet. And it's been quite a contentious point with our teachers because some of what you just cannot find, minutes, or how to post it and log it out even though we train all of them. It's for them to find that they can get on the site, but we haven't found a good tagging system yet—a good way to organize and tag. And really, I don't know how you call it, but make a nice table of contents and get an—it's kind of a jumbled mess right now.

In addition to navigational issues that slowed principals down during use, processing time also seemed to be an issue. Principal 6 complained: "It's taking a long time to load up." Requests for more efficient tools arose frequently and repeatedly; these ranged from stating that "HIDOE needs to get in the groove and acquire the tech tools for easy one-touch student data usage" (Open-Ended Survey Respondent 32) to wishing that if they woke up the next day and all their data challenges had been solved, they "would be able access it really, really quickly" (Principal 2). Even the way that LDS formatted exported data to be used in other systems seemed to slow multiple principals down. Open-Ended Survey Respondent 27 said,

> When exporting from LDS, I would like the Excel spreadsheet to be ready to use. . . . When exporting data from LDS to an Excel sheet, I spend an unreasonable amount of time eliminating columns from the Excel spreadsheet so that I may manipulate the data to tell me the information I need.

Data characteristics. Under the theme of data characteristics were two categories: quality and quantity. The evidence related to data quality converged around the subcategories of timeliness, relevance, reliability and validity as shown in Figure 22. Numerous terms used by principals, such as "lagging data," "old data," and "autopsy data," showed that they believed the data was not timely enough. With simple comments like "some of the data is not as up to date as maybe some other sources" (Principal 1), principals were critical of the value of older data. They indicated that the lagging access to data made informing decisions difficult. One noted that "from elementary feeder schools to our secondary school we only get a Strive HI snapshot and don't receive these scores in time to make placement and support decisions until after the school year has started" (Open-Ended Survey Respondent 35).

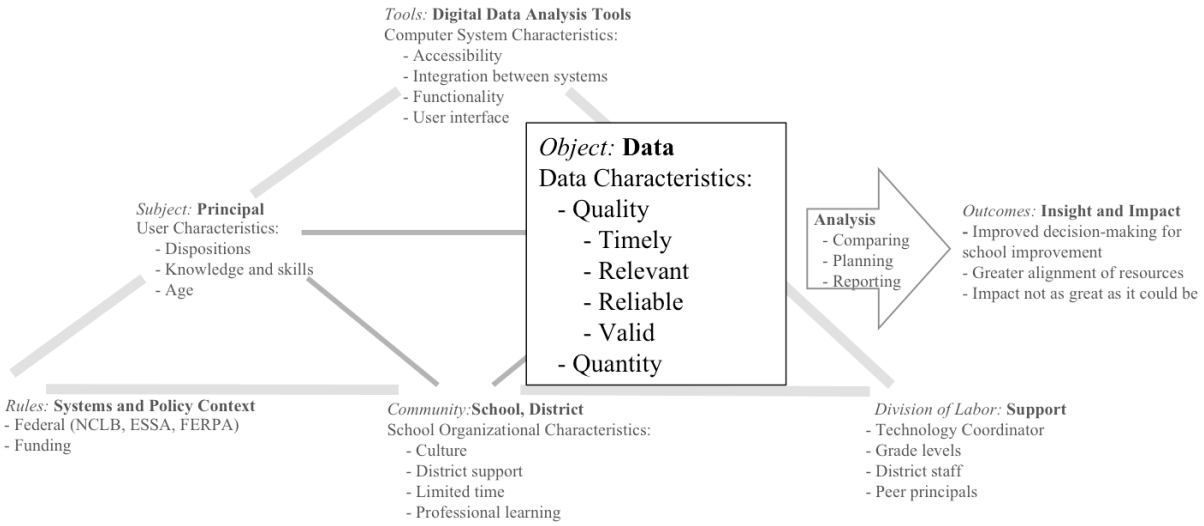

Figure 22. *Categories in data characteristics.*

Another stated:

> The most valuable data is that which is immediately available and relative to individual students, the school, and community. The difficulty in focusing on school-wide data in the public eye is that it doesn't always represent the whole school and community in snapshots that are months old. (Open-Ended Survey Respondent 26)

With the knowledge that existing digital data systems often provide lagging data, several principals reinforced the sentiment that resistance to overreliance on those data sources is important; in addition, educators proactively collecting their own meaningful data that can inform timely actions is also crucial. That sentiment was expressed by Principal 4:

> We do use the LDS. It'll highlight kids that are in trouble as far as grades and attendance and things like that. But I tell my guys that it's too late by the time the yellow or red light comes on in LDS. Sometimes they're 5, 10, 15 days of absence. They're already halfway to failing a course. So sometimes the timeliness of the data is not fast enough for schools

like mine that are very—we're a Comprehensive School Improvement (CSI) school because of our grad[uation] rate. Our population is very high poverty. So, I think for high-poverty schools you need a little more active data. I haven't found a platform that really tracks everything short of having real good communication with our teachers. Building good relationships with the kids and the counselors and really tracking them that way. There's not a system that I can sit back and turn on in the morning and look at and say, "OK, these are the kids that are here and there." (Principal 4)

When the data are not perceived as timely, users also think they are less relevant. The principal who submitted this comment on the survey reaffirmed that relationship between the characteristics of timeliness and relevance:

> There are lots of data in the DOE system, but because they measure quarterly, semiannual or annual test results and findings, I find no need to be constantly looking and trying to analyze what all this data means and how I can change my school. My teachers and nonclassroom teachers are my best source of what steps we as a school should be concentrating on or move towards. (Open-Ended Survey Respondent 15)

Although the majority of the student learning data that is supported by HIDOE digital databases contains annual standardized test data, educators find that to be less actionable. One participant used auto mechanics as an example of using tools to spend less time diagnosing problems and instead acquiring instant information to act upon:

> So, you know that that's the dream for me around data is that it becomes something that we don't have to chase, but it's something that is a tool that we use almost like, you know, I take my car to the mechanic. He plugs it in a computer; the computer tells him

> the air filter is clogged. He takes out the air filter. He puts a new one in, and I drive the car, so I spend most of my time about guiding where the car's going. So, it's that same thing—that even from complex support. Okay, your third graders are here in SBA. Here is where you can go in and at a really, really deep level see what you would need to do to get them going and caught up. More so than how they were weak in number sense. I don't really use that. That's old information. I really need to know. ... And what—what are the things that are the leverage things that I would do? ... As we have a change in teachers and a new generation comes, I think that they're going to be able to do that online in terms of look[ing] for strategies and stuff. (Principal 1)

Principals essentially want "live data" (Principal 4) in real time. Timeliness and relevance of data are two qualities that are interconnected and valued by users.

Relevant. Relevant data comprise information closely connected or appropriate for an intended purpose. Several principals stated that although they use the available data systems to generate reports, they found them less helpful than they'd like because the data points weren't the most meaningful to them. A few survey respondents talked about how the type of data impacted its relevance because users gravitated towards quantitative data, which might have been more available even though qualitative data might have been richer. The following comment revealed a sense of urgency to give more attention to qualitative data:

> We need to put emphasis on qualitative data that describes teaching and learning. Looking at data based on numbers is a rather flat and one-dimensional approach to understanding and responding to the school's needs. (Open-Ended Survey Respondent 63)

In addition to the type of data (qualitative versus quantitative), the level of detail available to principals was another factor related to data characteristics that caused principals to perceive the data and tools provided for them as less relevant than they could be. The following statement highlighted that concern in relation to the annual accountability report:

> The Strive HI report is also not comprehensive. It would be helpful to receive consistent and more detailed reports from our feeder schools in terms of how students are performing in reading, writing, math, and science areas in particular. (Open-ended Survey Respondent 35)

To increase the relevance, several principals stated their desire to be able to drill down and obtain more specifics about the underlying data used to generate summarized points:

> STAR data is the one that they feel most comfortable with. They've been doing it for a long, long time; but I don't know that it gives them—how helpful that data is. I don't know your take, but it's, to me, it's not—it's not to me. It's not definitive enough. Like, okay, needs work on introductions in his writing. Okay, well, that's a lot of things that it could be—or whatever those—whatever it might be—number sense. Okay, that's a big bucket. So what in number sense? ... How do we measure? And then we get that data and then at more of a microlevel because instead STAR and SBA and some of the other ones are so macro. They're so big picture, but changing in the big picture is the small daily lessons that you do to move the meter incrementally right now. (Principal 1)

Another way to increase the relevance of the data tools is to allow principals to input additional data points that could be integrated with existing information. While acknowledging

that the district supported LDS platform has useful information, some principals stated that it has limited value compared to what they want. For example, Principal 6 explained:

> We use it for attendance tracking. Especially for kids who look like they're attending less and less. You know, so that we can begin to target interventions for them and work with them on setting up a reward system to see if you can improve their attendance and come to school on time. Determine why they are not coming school. What can we do better? To instill that love of learning and wanting to be here. So, we look at that a lot on LDS. Their past through records, you know, in terms of—what was their involvement? I mean that LDS does have those features I'm talking about, but it's not the data that I want to put in as well.

In summary, principals seem to want access to more relevant and detailed data points into which they could drill down. The interviewees were helpful in clarifying what data they found relevant because the survey alone did not provide enough explanation. For example, principals reported using teacher observation data most frequently in the survey, but the interviewees clarified that it was actually informal walkthrough observation data being collected and used on a weekly basis because they found that to be more relevant in informing practice than formal observation data that is a part of teacher evaluations.

Reliable. Data that are consistent are considered reliable. Unfortunately, many principals questioned the reliability of the data from systems, given their negative experiences in the past. Several survey responses showed this trend. Two examples follow: "There are times when data are inconsistent in different systems, i.e., LDS vs. other sources" (Open-Ended Survey Respondent 3); "It is great to see the RenLearning data in LDS, but we have had trouble with the

information being either incorrect or there one day and missing on another day" (Open-Ended Survey Respondent 27). The inconsistencies were sometimes associated with the digital platforms as in the comments above, and other times in the metrics themselves. The principal who submitted the following survey response tried to create more consistency at the school level as a result of perceiving the larger district metrics in a constant state of flux:

> Data is a great starting point, but sources of data has to be consistent. DOE seems to change their measuring stick so frequently that it makes school-level decision a little more difficult than they want it to be. This is one major reason that I use my school's data to address my school's needs and move it that direction. Sometimes it clashes with what the state or district wants, but in the end, it is my school test results that they will look at and not care how we did it. (Open-Ended Survey Respondent 15)

A similar sentiment was echoed by an interviewee who questioned the results of the annual standardized test when performance tasks were removed, and the composition of the test changed from one year to the next:

> The numbers are much lower than last year, and I don't think we're unique in that. So, then there we go. So, the initial thing was upset panic. Right? And then we stopped. We looked at the data. We see a lot of kids were right about almost proficient. We see kids who last year were just barely made it. And then we said, "Well, what's different?" Between this year and last year with all things being equal—teachers working hard, doing the same amount of time—we still did RTI. So, these things—and then we get the different results. And so, in the initial part of that—then we're looking at—well, what did change? The test changed. Right? And then that could have had an impact. (Principal 1)

When trying to measure school improvement, principals typically wanted the metrics and the tools to be stable so that the changes in results can be attributed to the changes in their practice. They wanted to trust the systems and the data presented, so they praised progress in this area. Principal 6 said:

> The LDS is more stable than it has been in the past … easier to get the HSA or SBA data rather from both Aloha HSA as well as the LDS system. The fact that they all communicate with each other … I think that's really helpful as well. So you don't have one thing—something on the left hand happening that the right hand has no idea about. So I think the integration is good.

Another criterion for reliability was longevity in storage, which seemed to be an issue with some school-purchased subscriptions like Renaissance products. The digital STAR assessments used to screen students' ability levels in math and English multiple times a year did not provide reliable records of student performance over multiple years. Principal 1 complained, "This whole thing with STAR wipes it, so then we're having to back it up or print hard copies because their database doesn't keep it from year to year."

When asked to generate a simile in the following prompt, reliability was an underlying concern: Using digital data tools is like _____ because _____. Principal 1 responded as follows:

> Using digital data tools is like speed dating because you're not sure how it's going to turn out. And sometimes it's like, "Wow! I met this—I found all the data I needed, and it was in the form I needed it." And there's parts of it, you're like, "That works really well," and then other times, you're like spending hours doing something, and then you're like, "I can't get what I need," or "I can't do what I want." So then do I really want to go to

> speed dating anymore because the last seven were not very good? You know, I mean, and I don't want to spend my time doing something that. You know, I'm not getting something from it. But also, there's times where you're going, "Oh!" and you feel like you're pretty comfortable, and you're like, "I got something," which is probably sometimes a false thing because you might feel like you're better at it than you are.

Valid. Valid data is accurate. Principals sometimes questioned the validity of the data outputs because of questionable inputs and the measurement tools themselves. For example, Principal 1 questioned the effort that various teachers put into inputting standards-based report card grades and comments at the elementary level:

> And the standards-based report card is—I don't know—as a data source. I think that the teachers struggle with how comprehensive it is. There's a lot to input, whereas at the high school, grades are pretty quick, right? Yeah, and middle school. So, I think that also impacts. Some teachers spent days on it, and so, there's a rich source of information. And others say, "What's the minimum I have to input on the quarter report card or the semester report card?" Right? And so, then that affects the quality of that as a data source as well.

A trend across comments showed principals were keenly aware of considering the source of the data. Many questioned the validity of the source: "The data is only as accurate as the effort a student puts forth towards what you are measuring" (Open-Ended Survey Respondent 7). They know to look beyond a single data point because that might not necessarily be a valid representation of performance as shown in the following response:

> Students are constantly changing how they think and what they do, so to say one test on a topic is a true measure of a child's ability or capabilities is foolish. It's like taking a driver license test. … Most will fail the first time they take it, but does that mean they all will always be a bad driver? (Principal 6)

The same principal mentioned that it wasn't just about the frequency of data collection, but also the measurement tool itself that should be considered. Validity concerns were raised regarding multiple tools. The first issue had to do with tool design. Principal 6 commented:

> We used to have the DIBELS [Dynamic Indicators of Basic Early Literacy Skills], of course, yeah, which were helpful in terms of graphics, but it was misleading because it only reported that the correct letter sounds or reading fluency rates. And yet, all important questions at the end of the reading were left unchecked. So, I think, you know, that system could have been improved if they also recorded the check marks at the end of the passage. Because then that's the connection to the comprehension part.

The other examples cited by Principal 6 involved issues with the assessment methodology:

> I was just thinking I want to share something that, okay, this one is not necessarily a data system, but it's data related, and that's that the SQS [School Quality Survey]. Well, one, ... it's more of a climate survey. It's not necessarily a culture survey, and that's harder, I admit. But you know, I think if it's going to be a climate survey, then you know that climate changes just like how the weather changes, right? Because if I treated everybody to ice cream right before they took the survey, they might answer a little bit differently than if I yell at them. You know, it's. ... umm ... even like our testing systems, too.

> You know, are they really testing the true ability of our students? In terms of what they know and are able to do? And how do you separate that from their computer proficiency? Third-grade teachers were just talking about how the kids didn't know they had to scroll, keep scrolling to answer the rest of the question, so on their first pass, they only answered half the questions. So, when you look at third-grade literacy rate, you know, it's not just in terms of what they can do in terms of reading and writing. But those are not necessarily—it's more the data collection end. I think always when you get to be more efficient, things get lost along the way. Yeah, unintended consequences.

Although digital data collection tools can make some aspects of measurement more efficient, a danger also exists that digital literacy skills can conflate the results. For more than one reason, the validity of the data remained a concern.

Quantity. In addition to the data quality issues, the sheer quantity of data was also a factor that influenced principals' ability to use them. In the survey, principals' comments varied from a subtle "We have more than enough data available on our students" to a stronger negative reaction like "It is a challenge when there is so much data!" Large quantities of data caused difficulty for some principals to navigate and analyze information as described by Principal 4:

> Presently, there is too much data, so it's difficult to sift through to determine the most important needs of a school, or individual students. I agree that data is important; however, when a school has a high rate of transiency, it is a challenge to determine what is the root cause when students are not performing at their expected level.

In summary, the data characteristics that seemed important to this population included type of data, timeliness, quality, and quantity. One principal summarized the confusion well: "The data

characteristics are nebulous when ascertaining whether they are current, relevant, available, and holistic" (Open-Ended Survey Respondent 26).

User characteristics. All factors that varied by individual user on a personal level were categorized under the theme of user characteristics. Most of the demographic factors considered in the survey, such as gender and island location, were not mentioned by interviewees. Instead, knowledge, skills, and dispositions that individuals possessed were raised far more frequently, so those were prioritized toward the top of the list followed by age as shown in Figure 23.

Dispositions. Dispositions that include inclination toward data use comprise the beliefs and attitudes of an individual. One principal commented, "Not everyone has the same understanding or belief about how data is best used" (Open-Ended Survey Respondent 40). Educators who believe in the importance of the use of data in determining needs were more positive about incorporating data in their daily decision-making. One positive disposition that emerged as a trend in this study was a growth mindset toward learning and growing personally,

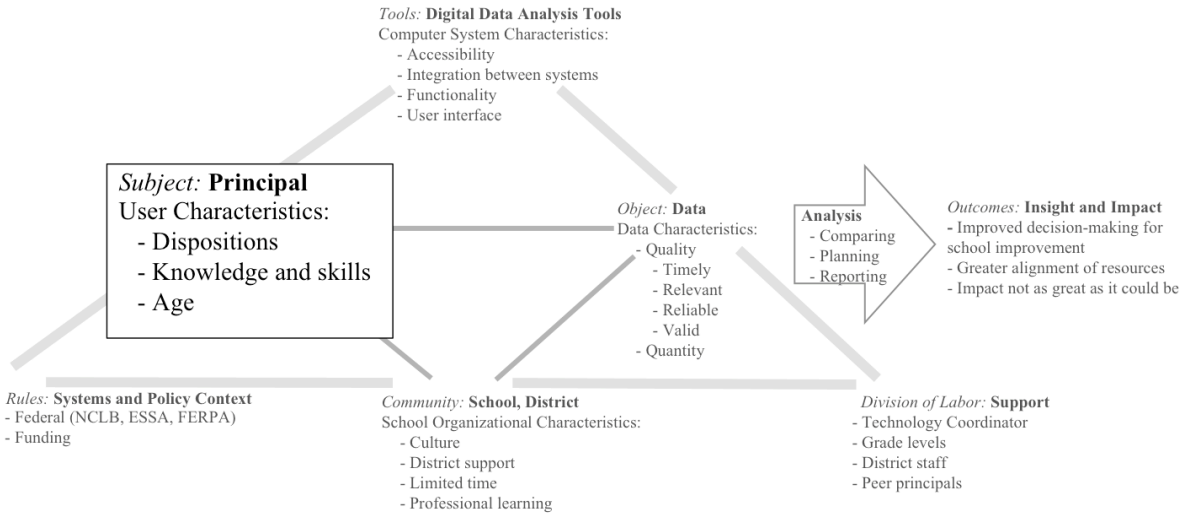

Figure 23. Categories in user characteristics.

which was evident when participants talked about always seeing room for improvement and more frequent use. The statement below displays a willingness to learn based on necessity:

> I mean, obviously I'm kind of a person that's maybe different because I like tech and I want to grow in it. But I'm not one of those principals that's like [name redacted] who's like a vanguard of technology. He could be an IT guy for the state. I mean he's that way. I'm more of—Okay, what do I need today? How do I get what I need to get? (Principal 1)

Comments at the other end of the spectrum ranged from "I'm feeling quite rusty right now" (Principal 3) to "I just don't know anything about tech, and you know, I'm terrible" (Principal 2). Negative dispositions and fear of learning something new were barriers to using digital tools. Principal 4 noted that he and his peer principals sometimes adopted a negative disposition stemming from bad experiences in the past:

> They could be like me and don't understand it real well. A lot of them may get frustrated with the type of data that's on it. You know, a lot of them don't see the need to use the data. I want to make sure that it is useful. I'm not going to go collect data if it's not gonna be used. And recently we've been collecting a lot of data points that we ask ourselves as principals, ... "What we collecting these things for? What is it going to be used for?"

Statements revealing a disposition toward using data and digital data tools were often accompanied by statements about how they perceived their knowledge and skills.

Knowledge and skills. Skill level is a factor that can impact users' confidence and disposition toward tools. Users' self-perceptions as lacking computer skills shaped their interaction with digital tools. For example, when talking about using digital tools, Principal 2 said:

> At first it gets all—it's overwhelming—because everything it's new … and it's like, I don't have a computer. It's the worst because I can't use the PC. [She continued.] To be honest with you, I guess I'm not that kind of administrator, or you know, I check my email, … but I don't check my e-mail till—lucky, lucky, if it's 4:00, 4:30, and most people go home at that time, but to me that's ideal because I'm all over the place.

The skill for both executive functioning and knowing how to adapt to different types of machines can impact a user's ability to use tools.

Principals across the spectrum of skill levels were interviewed in this study: from those who felt nervous on a PC to those who had work experience in other industries with transferrable skills. Principal 6 explained:

> I think for myself. I feel fortunate because when I went to school, I graduated in engineering, so I did a lot of computer science and programming. And so I was a tech coordinator at [name redacted] High School. A lot of experience with the technology, so in that sense I—I feel well-positioned.

Often when principals encountered a barrier in using digital data tools, they attributed the setback to their own skills and not the tool design. Many principals thought their skillset was limited. Principal 4 said, "It probably can, but because I'm not that great at it, it doesn't come easy for me; but my VPs are pretty technology savvy, so if they see something, they'll use it."

In the following quotation Principal 1 generalized that most principals have a limited skill set in which the potential power of the digital data tools they use is not fully exercised:

> My initial understanding was LDS was going to be able to give me—like if you were a ninth grader—that I was going to be able to really get some great information. Okay, you

know what I mean—through your whole career—and really see that. The faults, and I'm—I'm going to be honest about that, the fault may be in me more than any other. Wiser people might say, "Well, yeah, you can see all that. You just need to do dadada." … I don't feel like most principals. I think [name redacted] is really far down the road when he has spent time on it, and he was always wired that way. But he's really gotten in depth. I don't know that most of us as principals have the ability to really, um, do that piece. I never see anybody do it at that level. So, it's at that level I'm not aware of.

The range of technical skill levels among educators varies considerably, extending beyond what was captured in this study. Although acknowledging that it is important to develop technology skills in the educational setting, one principal highlighted the need for technology skills to be balanced with pedagogy and other skills. If overemphasis is placed on the use of digital tools, users might not strike the ideal balance of multiple skill sets. Principal 3 commented:

I just think that, uh, you know, we have the spectrum of digital use here on our campus. And you—we have people that are completely anti anything technology. It's just straight paper, pencil, workbook. And those are not bad things. Okay, and then we have the flip side, where it's nothing but the iReady program. So they just have—like literally there's two seventh-grade math teachers. On Monday or like the first—the first time they see the kids three times a week—the first time we see the kids, it's iReady day. So the kids login to iReady because iReady has online classes linked to that screener, and so it's all leveled. Leveled to like their playing field. And then they gotta learn these different concepts that are showing up as weak. Right, so the first day they did that. The second

> time they see the kids, they do GoMath! on the computer, so then kids log in to GoMath! and do that. Then the third time they see him they do IXL. So there is no instruction happening. They are dependent on these programs to teach the kids. So, I think what I would say is that digital tools are great, but they're digital tools, and they are not a digital teacher. The strongest growth you're going to see in kids in achievement is going to be a balanced approach to use of digital tools with strong instructional practices. You have to teach the kids. And it's a matter of personalizing, I think every child's education—but understanding that you can use digital tools, and you can use face-to-face, and you should be using both, but that there is a balance for every kid.

Knowledge and skills related to technology are often interrelated to other important skillsets. For example, a need also exists for data literacy skills. While acknowledging that the lack of consistency in understanding data is still a problem, one participant commented that "statistics literacy is not universal among school, district, and state leadership. This impedes discussions around the use of data and decision-making" (Open-Ended Survey Respondent 25).

Age. When reflecting on their own skill level, half the interviewees made reference to another user characteristic: age. As a Baby Boomer, Principal 4 made several references to his age in connection to the need for training:

> I guess my generation is low tech, so I have people that do it for me, or do it with me, so I can get it done. … Old dogs like me are hard. We need a little more training and understanding of what's going on. I see the importance of the data, but it's like because I don't know how to use it really well and certain programs, I need the assistance on that.

Similar comments about age were made by half the interviewees. In stating that their age was a factor influencing their skill level, principals often asked for additional training. Principal 1 stated:

> So, you know, I'm—I'm old. I get that. I'm 52, soon to be 53, and you know, so I remember going to Costco and getting the—you know, the DOS computer because I was really cutting edge to do my educational work. I remember Apple II. I remember all the things. I think we've come a lot. I'm not going to say we've come so far, but I think that the challenge is around training.

In addition to comments about principals' own age, several comparative comments were also made about younger staff members. Principal 2 associated youth with technology proficiency: "So my AC is real good because—it's interesting—because she's like 30. I think she's 31. I don't want to bother her. But then she sees the texts. They liked texts, my teachers. I don't answer the texts."

Another example follows:

> So, like we have some teachers that are generationally probably closer to yours, that like technology for them is like, I'll just whip up data spreadsheet for all of us, and we all can use it in Grade 2. And I look at it, and I go, "Wow, that's really kind of cool. I had no idea." (Principal 1)

Although age was a factor associated with the experiences of several interviewees, other user characteristics like race, gender, and geographic location were never mentioned.

In summary, variation in user characteristics was expected. Looking at the organizational supports in place to sustain the wide range of users in the system was critical. The next section

contains and examination of evidence from this study that provides a picture of school organizational characteristics.

School organizational characteristics. Organizational characteristics that impacted data use in the literature included the structure, vision, norms, leadership, support, collaboration, and resource allocation (Schildkamp, 2016). The four main categories that emerged from this dataset as organizational factors of importance were culture, district support, limited time, and professional learning as shown in Figure 24 and described in the sections below.

Culture. *Culture* denotes the attitudes and behavior characteristics of a particular group. When principals described positive cultures surrounding data use, they often talked about engaging with technical tools together and looking at data as part of a regular routine. One participant said:

> The most effective ways we use data are through well-developed systems, such as Early Warning Systems, in which we meet with teaching teams about once a month and review

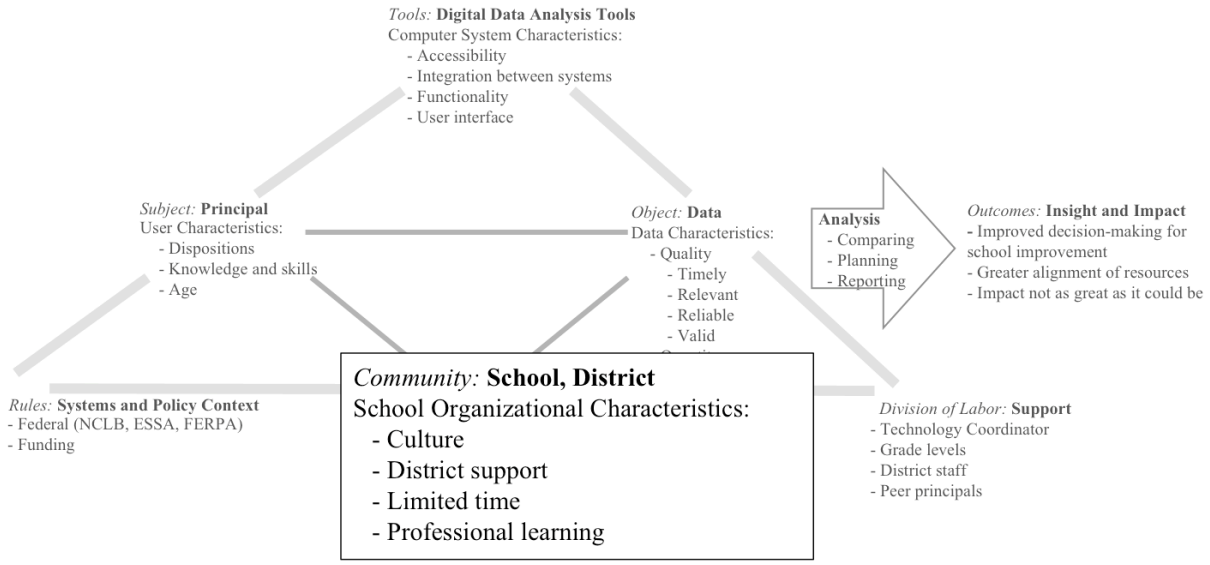

Figure 24. Categories of school organizational characteristics.

> performance data, PLCs, the ART team, and other RTI intervention teams. (Open-Ended Survey Respondent 35)

In describing collaborative cultures where individuals take the initiative with data, principals used words like *we* and *our*. In the following example, Principal 1 discussed teacher teams that designed their own data systems:

> Beyond SBA we create our own spreadsheets for more local school pieces, and we have data reports that way. So especially around, um, microdata where grade-level teams are doing a lot of that is self-generated spreadsheets, data collection sheets, right, to track students in a particular grade level so that they can look at where they are.

Principals played a major role in creating these cultures. As shown in another example, the tech committee and STEM committees conducted school-wide trainings, and the principal intentionally joined the group to lead by example:

> Their onus of responsibility is to make sure that we do trainings, whether it's Google 101 when you're new or how to do Infinite Campus. They also are the ones that screen the people that we—we send at least four or five people to the Institute for Society and Technology Education [Conference] every year. It's very important for them to go and see what's new. What can you bring back? They're challenged to bring it back and introduce at least two things to everybody. . . . They can share with the faculty at least one one-hour PD so that they can be the ones introducing this to peers saying, "This was great. You should try this. This is a wonderful thing to do." Including me. I brought back Accelus. And so we will put together a PD on all of that. So, every year we do this to try to keep up with the pace of everything. Even Google has changed our whole classroom. (Principal 5)

Sometimes the tools themselves seemed to shape culture and become a part of staff identity to the point that schools called themselves Google Schools. The story shared below by Principal 4 exemplified a cultural shift:

> Using digital data tools is like a caveman trying to start a fire. So, by the way I see it, it's difficult to start, but once you get started, it'll catch fire. Well, the key is finding that little spark. So we use Google a lot. A lot of our staff they don't want to use it. They're kind of afraid to learn something new. But once you got that spark; then they could see the good features in it, the way that we could communicate better. Then it kind of caught on. So, we do everything not paper now. All of the bulletins, everything we don't print bulletins any more, menus and stuff like that. So, everything is all ... online.

Principal 4 proceeded to describe how embedded digital tools are in their collaborative

culture:

> As far as what we do on a daily basis, I'll use Google because it'll keep us current with what we're doing. It's an active tracker, it's an active involver as far as our meetings go, because that's one of the reasons why I use it and I like it. Because at times not all of our administrators can get together. So, we'll use it, and somebody can be remotely away and still participating in our meetings. So, we do it that way. We have consistent meetings.

One third of the interviewees made statements showing a deep connection to Google tools, making remarks like "We're all about it" and "Google Drive is everything that we've got" (Principal 5). Although positive cultural shifts supported by evolving tools constituted a common trend, several challenges remained related to staff culture.

Three comments were made by principals using the word *difficult* while talking about school-wide culture and data use:

1. "It is difficult to use data when some teachers are very resistant to look at how much students have learned in a year rather than how much they 'taught' in a year" (Open-Ended Survey Respondent 20);
2. "It is difficult to convince some teachers to use data in their practice. Mandated use may lead to teachers seeing the value of using data—eventually" (Open-Ended Survey Respondent 36); and
3. "We analyze data, but it is difficult to empower change as a result. We have pockets of analysis, but it is not school wide yet" (Open-Ended Survey Respondent 40).

The challenges surrounding culture that they described dealt with mindset, individual willingness, and scaling success.

Lack of trust was considered a barrier to deeper data analysis both from teacher to teacher as well as from teachers to administrators. The following example shows both:

> It's the kind of teachers … They don't trust each other. They don't trust admin, so ... it's like they don't have a leadership team. … It's a matter of trust. So, I introduce them to—because they don't have—like a protocol to look at student work. It's all they're getting to; I guess it's—it's really trusting your colleagues to trust them. But that's how it's been here. So, I'm slowly trying to—it's hard to get teachers to [open up]. But if you don't self-reflect and you don't go back to—you know, Gee, maybe I need to look at what I'm doing, you know? All you have to be able to be open and have understand what it means to trust that nobody's going to put you down. You know you're doing it because you want the kids to benefit from it. (Principal 2)

When data use is connected to evaluations, an added power dynamic is inherently involved. A survey respondent stated, "Unfortunately, people use data as an evaluation tool rather than a learning opportunity" (Open-Ended Survey Respondent 31). Two principals shared negative experiences in which teachers filed grievances with the teachers' union as formal complaints about the use of data. One appears below:

> They tried to file a grievance against me while I was monitoring the amount of kids that were being sent out [of the classroom for disciplinary reasons]. So what classrooms were they being sent out from? And so, what I did was I compiled the top 10, and there were major discrepancies. Some teachers had 10 kids like there. Like 140 kids. It's not just kids, but times. Instances, yeah. So, I hadn't met with the teachers, and I talked to them. How can I help you? That's a lot. That's a lot of kids being sent out. And so, so some of

> them were like, "What is this? This is some kind of disciplinary tactic like you're using this [alternative] room to discourage us from being able to refer kids out." So, they tried to file a grievance, they went through the APC, and I just told them. I said, "There's nothing you guys can do. I have the right to look at data. I can take this data from eCSSS. I can take this data from our own spreadsheet." I said, "The issue here is we have teachers who are sending kids out all the time." As the administrator it's my job to help find support so that they can improve practice or improve in some areas so they're not sending kids out. (Principal 3)

In the last part of his statement, Principal 3 took responsibility as a leader to use data as a way to help find support that will improve outcomes, but that mindset clashed with the current culture of the faculty.

District support. Most principals in this study mentioned receiving support from both the Complex Area district staff as well as state office staff. One of the six interviewees stated that district support was seriously lacking: "The district doesn't give me anything—not really getting anything from the state" (Principal 3).

The other five interviewees shared stories of district support staff and trainings they had provided. For example, when talking about a specific training on the LDS to look at EL data, this principal spoke enthusiastically about specific trainers from the district:

> You know [what] was really good? When we had [district trainer, name redacted] 'cause she had that guy with her. They're really good. They're very patient and because they're familiar. If you're not sure, you just ask them, and they'll be able to help you. Yeah, so they're very—they were really good. (Principal 2)

The district and state experts provided help, but not necessarily on a frequent basis. Most shared stories were about isolated and infrequent training events provided by district personnel. Principal 6 said, "I'll call the guys I know at state, but rarely. I think most of times we can solve the problems here."

In other contexts, the principals stated that the district support could both boost and block to data usage. As a boost, principals attributed their increased use of tools at least partially to the partnership with district staff. For example, Principal 1 said, "I've gotten better about getting into, um, LDS and we have a complex SRS that has helped us somewhat with starting to use this more." In the trilevel organizational structure of the HIDOE, several functions impacting data use at the school level were controlled at the state-office level. For example, personnel at the data governance office could decide to provide and support tools like LDS, and they could also decide to block certain tools from data sharing agreements. At the school level why certain tools were blocked by the state office gatekeepers could be unclear. Principal 1 continued:

> At one point what the state say goes, so that's why we have LDS, and we have other systems. … And it's, "You don't need to do this one," and then there's been this fight going back and forth, and he just told us that his retirement principals be that, "Oh, by the way, you're going to have this now."

Half the interviewees expressed confusion around the FERPA rules and regarded them as a deterrent to using data analytic tools and other technology. Principal 5 stated:

> I like where we're going with education and technology. I just hope that the DOE can keep up. They haven't been. You know, like Google. It's takes us way too long to get some sort of approval with this thing. I mean. Come on. ... You know it's Big Brother.

> Big Sister. I mean, look, they hacked into the government. There's only so much we can believe. We can try to block. And if we continue to not move fast enough, our kids won't be up where they need to be.

The perception of the district as not keeping up with advancements in technology was seen as a barrier instead of a support. The state level of the district office served in many support roles, such as managing data privacy and sharing agreements, ensuring data security, providing infrastructure support, training, and funding, to name a few. Most of the time this centralized control removed the burden of school level personnel to fulfill these functions, but sometimes this centralized control negatively impacted schools. In the following example, Principal 3 recounted receiving funding from the state for a contract with a consultant group to support him with generating data spreadsheets tied to instructional change, but then that funding shifted from the state level.

> But then they ended our funding, so I don't get to do Year 2, which I'm super pissed off about. …You know, I really, really took advantage of the School Turnaround stuff, and it really helped me try to craft this idea, or you know, just like, What can I do to help our teachers improve, you know, instructionally? (Principal 3)

In summary, the district support has been perceived both to boost and block at times with regard to principals using data analytic tools.

Limited time. Time was a major organizational factor influencing the availability of principals to interact with data. One respondent put it plainly: "The resource of time does impact the engagement of data analyses" (Open-Ended Survey Respondent 26). Describing the normal workday of a principal as "crazy," all of the interviewees lamented that they had insufficient time

during the day to spend with data that they believed were critical. Without time built in, all interviewees said they engaged with work data outside the workday, in the early in the morning, or late at night. Analyzing the data at odd times impacted principals' skills. One said, "You try to do it when you're tired, or you're trying to do it on the weekend, and you may or may not know what you're doing" (Principal 1).

Limited structured time for using data analysis tools has also hampered principals' ability to learn all of the functionalities of the tools and become proficient in them. During the think-aloud, a principal discussed how time impacted his ability to learn how to pull a certain report from the state-provided student information system. "Yeah, it's in—I know it's in Infinite Campus as well, but I'm still struggling, and I haven't dedicated enough time, I think, to learn it. But those are the kinds of things I want to be able to do with Infinite Campus, but I haven't been doing yet" (Principal 6).

This was a common perception among principals in relation to multiple tools. Principal 2 said:

> I still don't know how to fully take advantage of all the features of Lotus. Okay, but when do I have the time? I usually take my vacation, you know … right after that first weekend in June and then come back, and do you know I've got to do interviews. I've got to do work on my campus. I just got off the phone.

With limited time to examine data and limited time to learn to use the tools, principals became especially frustrated when the tools themselves seemed less than efficient with regard to time. For example, two principals shared similar complaints that the LDS tool formatted data in a way that consumed too much time. One stated: "When exporting data from LDS to an Excel

sheet, I spend an unreasonable amount of time eliminating columns from the Excel spreadsheet so that I may manipulate the data to tell me the information I need" (Open-Ended Survey Respondent 27).

By contrast, some interviewees recognized improvements in digital data tools that increased their efficiency and freed up educators' time. Principal 1 recalled his past experience with time-consuming data entry, comparing it to present efficiencies:

> And even around the data for teachers, I think we used to ask teachers to collect data. I think now our movement is towards how can we create systems in which teachers have access to the right data that they need. So, then they can spend their time on what they're going to do with that data, whereas before I think we went through a period of time—it was about where we're going to build systems of collecting data. The more that we don't have them collect data, my hope is then we can have them plan around the data because collecting the data sometimes becomes the whole thing, and even as a principal, do you want me spending all my time sitting here and inputting student names? I remember doing this for 500-something kids, whatever scores, they are entering an Excel spreadsheet, so then I'm going to compare that and the formative assessments around—toward the assessments or whatever. Do you really want me to spend seven hours on that? Or do you want me spent seven hours about—okay, what am I going to do? How are we going to attack this as a school? How are we going to change instruction? … Dadada. So, you know, that that's the dream for me around data is that it becomes something that we don't have to chase, but it's something that is a tool that we use.

With shifts in tools have come shifts in practice. Several principals stated that they foresaw an optimistic future, where efficiency would continue to improve, and educators would have opportunities to have the conversations they needed to have in order to make a difference. They compared that hope to the current reality, in which time was still a negative factor, influencing what data was collected, when they could look at it, when they could learn more about the data analysis tools, and when they could collaborate with others using data. Five of the six interviewees shared anecdotes about teachers having time to look at data in data teams or in professional learning communities (PLCs) but noted that they were not typically involved in those meetings, so they lacked that dedicated time in their schedules. A newer principal shared that he was still trying to work out the timing of when to have collaborative conversations with teachers about data along with which tools to use. He said:

> There's a lot of things that I'm still growing in[to] as a principal and trying to figure out like where is that, how to work out the timing for it, when, you know—when I meet with these people, what do I say, how do I craft that conversation? I'm taking this kind of data. I've analyzed it myself and made tables. I've gone into PLCs. (Principal 3)

The lack of time along with a steep learning curve was connected to the next factor of data use: professional learning.

Professional learning. Interviewees had much to share about professional learning with the majority of the comments linked to the desire for more training and support from the district. When principals were asked on the survey what else they wanted to share about data use as a principal, many commented on the need for training. Three such comments indicated a need for training with regard to the way the tools worked in the specific context of the DOE system. One

responded, such as, “Everyone needs to learn how to use data effectively. The tools should help more than they do!! Professional development and systems alignment would help” (Open-Ended Survey Respondent 40).

Others indicated that training should be more ongoing and that the scope should relate to the school level. One participant said, “We need continued PD on data use and implementation at the school level” (Open-Ended Survey Respondent 3).

The current support was perceived as insufficient and too inflexible to accommodate various learning styles as Principal 6 noted:

> A lot of the training that we get is just a one-day thing or half-day, even. You know, here’s LDS, and here’s, you know—And yet, you know, between then and the time they need it, there’s a lot of time that has passed, and so you don’t get, I think, the on-demand type of training or help that you might need. I look at my daughter, who’s a senior; my son, seven. And whenever they need to learn how to do something, they are looking at YouTube, even my younger teachers, you know. They are like [the] YouTube generation, you know, and that’s—that’s how they learned to do things, or they’ll go onto Khan Academy, you know, and it’s—I think for our generation, or my generation, that it’s less comfortable to do that and we’re not as used to. But I think that’s where we’re moving towards. So how do you get on demand? Because there’s no way that we’ll get to have a tech person on campus who’s on every campus that they can attend to those needs.

With limited resources available at the school level, principals looked to the district to provide training and support. Principal 4 described a particular training at the school level that was helpful and expressed a desire for more training:

> I think I would like to have more training, but there's none available right now for principals in our district. I'd love more district support, but it seems more to support the network itself instead of supporting us in what we need to do. The data governance has been helpful. When I give them a call for math, my math teachers wanted to see how to use and create certain reports and stuff using LDS. And right away they made arrangements to come. So they're doing the training on LDS to show them how to use LDS, break everything up. So, I think training and specific training per school was important. Okay, so knowing what the school needs and then designing it for the school. Yea, and they were real good. LDS was really good about that.

The experiences with and perceptions of support certainly varied by principal and was a factor influencing their confidence with regard to using various tools. The following interview segment demonstrates that some tools seemed more immediately intuitive than others and thus might need different amounts of training to help support principals. In his comments, Principal 1 questioned why some tools—like the evaluation tools—were accompanied by substantial training, but other state-provided tools were not supported to that same level. He said:

> I think that the challenge is around training. Like Aloha Tide is very relatively intuitive. So there's not a lot you can find there, but you can find what you're looking for. Now maybe I would rather a depth of more really detailed analysis of what students did and didn't do right or the ability to generate disaggregated reports. Those things will matter to me—that I'm not very good at. Maybe I'm not trained, but overall, I can get in that site and get and see what I need. I think for demographics the same is true. So I don't know where I was trained in that or that was just those are easy obvious pieces because I don't

feel like I've gotten a lot of training. I mean either with a CISL ACE component that's certainly not something you spend time on. Um, my master's degrees from California back whatever, they ever did teach us if anything around was Excel. So, I mean it's like riding horses kind of stuff. So [name of Complex Area support staff redacted] has done some for us and has mostly been exposure. So mostly just said, "Hey, here's this thing. You guys can kind of like spend some time on it." I think unless if you really wanted me to grow. Oh, and my expertise on EES is—and that's a place I obviously go is into the PDE[3] site for staff things, right, and data around them and their performance. That is the one I'm probably the most expert on. Well, but that's also the thing. I've almost received 30, and I'm going to get retrained this summer. I received 30-plus documented hours or whatever it is, right? We had those formal things, and we had to show proficiency, right. So, in our learning, we had to know and then we went. We had many, many hours, and then we got to practice, and then we had to know. We had to pass this thing, and if we didn't pass it, we're going to have to do it again. So the motivation level was [there]. So, we're all experts in EES even though that's greatly dropped off the map, right? Right, ... but that's probably one thing I would say. For me I'm most proficient in because I use it all the time. I was well-trained in it, I got lots and lots of hours of it, and it was something somebody said to me, "You need to know how to do this." … But you know, I'll go to another day training this summer. I'm not going to another day training on LDS. In fact, I've never gone to a training on LDS other than with Complex Area support. And so it was. I feel like that's been kind of the things with Achieve or SFA or those kinds of things. Those companies put on trainings, so I've developed a certain amount

> proficiency. STAR. We felt STARs—just to me—too cumbersome. The teachers like it because there are certain reports they want to look at. But beyond that the rest of it is very cumbersome to use to me. But they'll do the training if we ask, so outside providers normally will give us more; but I haven't been trained a lot. But I will ask for help if I don't know what to do. And that's where sometimes other staff members or district people can help. It's more at a local level. I don't know what the state upper-level OCISS or whoever else to ask for help anyways.

Principal 1 acknowledged that confidence and competence were related to the amount of training received.

A trend surfaced among principals in which they noted a difference between the level of responsiveness they received from the district supported platforms versus paid providers, such as Achieve, Success for All (SFA), and STAR. They perceived that state office support was not structured to visit the more than 250 schools for individual school trainings. Principal 2 noted, "It was almost like a moratorium—you cannot go to the school level. … They can go down to the complex."

Regardless of the reason for lack of training, participants generally expressed a desire for more training on data analysis tools along with various uses. Comments, such as "I would like to have more systems training on data. For example, how to create pivot points, databases, etc." (Open-Ended Survey Respondent 17), showed that some principals wanted to learn specific technical skills for working with data.

Others wanted more training on the analysis side as shown in the following: “I can always use more training in analysis, relevance, and motivating teachers to use” (Open-Ended Survey Respondent 54).

Comments about looking outside the district for professional learning were rare, but two of the interviewees mentioned the benefits of national conferences, such as the International Society for Technology in Education. Those who had the opportunity to learn in those settings enthused about how impactful they had been in inspiring change not only in themselves as leaders but also across their schools. In the following, Principal 3 expressed disappointment that recent policies discouraged employees from participating in off-island conferences:

> I mean the greatest thing for me was going to Edtech conferences on the mainland, which are now damned. I went to one CUE Leadership 3.0. I went to them three years ago, ... and so I went up there, and then I went to these different workshops. And that’s where I learned all about Google Classroom. I learned about the use of Google Forms, of the different add-ons. I learned about these different extensions. All these different applications up there, these formative assessment tools, these summative assessment tools, these like just instructional applications up the ying yang, and it blew my mind. Holy cow, we are so behind the times, and it just so happened that that is when we found out that we got this Digital Promise Grant. So that’s where our entire school was outfitted with iPads that came with data. Wow! It was funded by Verizon, but it went through what’s called Digital Promise. That’s the organization. And so literally, like, my mind was blown, going to that ed-tech conference and then find[ing] out that we’re getting all of this technology because we are a very low-tech school, and we’re getting all these

technologies. Like, ho! This is crazy. And then over the next three years there's been a heavy focus on technology at our school.

Especially with the isolation resulting from living on an island, principals viewed conferences as a beneficial practice of learning from others in educational leadership roles out of state, but those opportunities could be jeopardized by budget restrictions and district travel policies. One mention was made of a principal seeking out an online webinar to advance his skills, and he did so in order to learn more about the Student Information System features. A crossover between comments related to the need for training and user characteristics, such as age, appears below.

Other analyses. Additional analysis from the qualitative data was noted as it aligned with contextual factors in the community related to policies, rules, or division of labor as shown in Figure 25. Under systems and policy context, previous examples were mentioned related to funding such as the negative impact of limiting funding on data analysis work. Other examples related to the nested district and federal policies including the way that interviewees talked about how the FERPA regulations were interpreted and applied in a way that restricted information sharing between teachers at the school level. Although these factors were not the focus of this study, they were uncovered in the findings and noted as part of the context for the system.

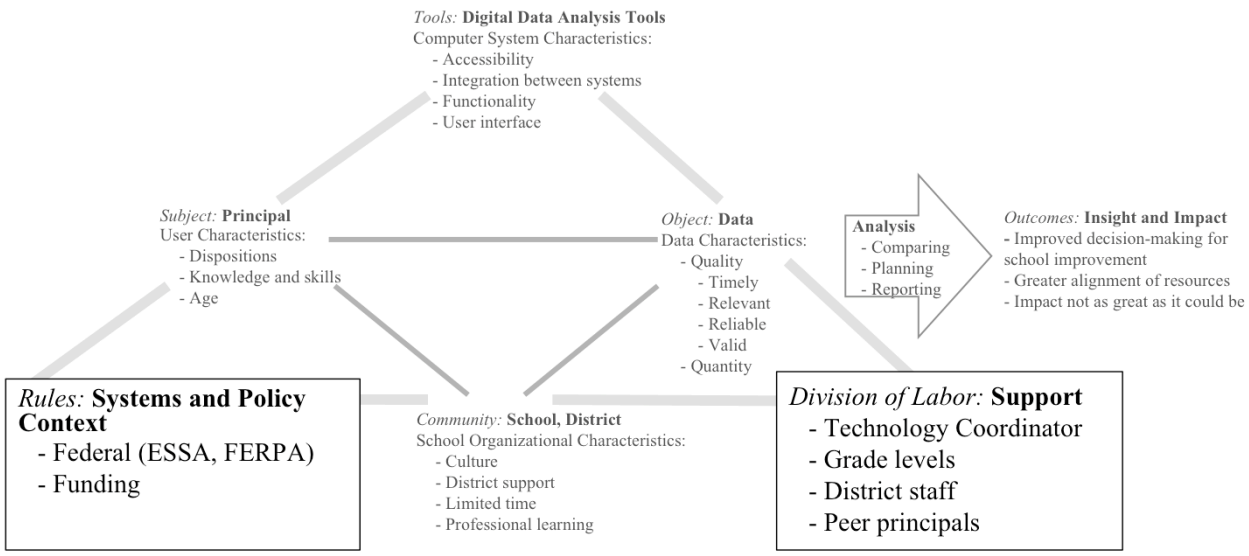

Figure 25. Additional systems context.

The category for division of labor encapsulated community members that took part in this work such as technology coordinators, grade level staff, district staff, and peer principals. Given the busy schedules of principals and their limited technical training, many principals relied on the support of others to help them with data analysis activities. Interviewees shared stories of school-level personnel like grade-level leads particularly savvy with technology (Principal 1), technology committees that led trainings (Principal 5), or program leads who generated reports for the principal (Principal 4); but the trend with those examples was that support varied by the individual talent and school design. The division of labor was inconsistent and varied considerably by school. In the following example, the principal was able to use a support staff, who was on campus only part time:

> We have a tech person on campus who is here three days a week. He's very helpful. I'll call all of the guys I know at state, but rarely. I think most of times we can solve the problems here. I play around, and I just try and like figure it out ... just stumble through

it. Well, ... the rest of my staff, all of them are very good at using spreadsheets but not beyond that. Novices when it comes to even accessing LDS, and so we're trying to train and learn. (Principal 6)

Technology coordinator positions were not guaranteed at schools and vulnerable to shifts in funding. Some schools were highly dependent on people in this role to support both principals and teachers as shown in the following example, offered by Principal 2:

I usually [let] my tech coordinator do all this for me. That's the nice thing, but next year I'm not going to have a tech coordinator because my school is so small. I just can't [afford it], you know? He pulls everything, and then he kind of puts it in a form that is easy for even the teachers to look at the data and everything. So for SBA, he'll put like, for example, you know, it's by the strands, right. So he'll do all of that. And then he has the ones with the kids' names. So, it's really—I mean you know— I don't have to do anything.

Because the HIDOE is a trilevel system of support, examples of Complex Area and state district personnel supporting principals surfaced in this work, but those examples seemed to vary by geographic region. As noted above, some principals perceived a lack of support and training from the district, but others named specific people at both the Complex Area and state offices who have helped. Another shared the lack of responsiveness from the district stating, "The only data at this time I am not able to understand is the SPED Inclusion percentage, asked district and state for explanation, but have not received anything back yet" (Open-Ended Survey Respondent 45). A general sentiment indicated that principals would appreciate more help and designated support staff because "effective use of data requires additional staff support" (Open-Ended

Survey Respondent 21). Although the interviewees never explicitly referred to national policies, Principal 6 referred to his school's status as a Priority School, a designation that emanated from the local accountability system in compliance with federal regulations. Local policies that impacted their practice derived mainly from funding changes that prohibited them from continuing a support program or restriction on travel to professional conferences (Principal 3). Overall, factors influencing data use were varied, complex, and interrelated. Evidence showed that factors seemed to change with time as tools were enhanced, organization structures changed, and policies shifted.

Comparison of Quantitative and Qualitative Results for RQ3

In comparing the quantitative and qualitative findings related to the factors that impacted data use, more discrepancies emerged in these datasets than for the other research questions. Although the larger population of principals generally reported positive responses on the survey scales for Computer System Characteristics and Data Characteristics, the sample of principals in Phase 2 were often observed struggling to use tools and spent considerable amounts of time describing the challenges they faced. This may have been the result of survey prompts that were general statements as opposed to the think-aloud and interview protocols, which focused on specific tools and may have prompted the identification of more specific challenges. In another example, 88% of principals agreed or strongly agreed that they possessed the proper technology to efficiently examine data, but then only 19% agreed that they could find all the data on students in one system, which was a need echoed many times throughout the interviews. Another contradiction was identified in the area of support. Specifically, 71% agreed or strongly agreed that they were adequately supported in the effective use of data on the survey, but then the

majority of interviewees described how lack of training and personnel support was a major barrier to use. These examples confirmed the benefits of using a mixed methods approach to fully understand user experiences.

Research Question 4: Impact of Data Analytic Tools on Principals' Work

Deeper insight into how data analytic tools have impacted principals and their work was primarily collected through the open-ended questions in the semistructured interviews. Principals described the impact of using data and data analytic tools, using a range of descriptors. Some principals described data use as "an integral part of what we're doing" (Principal 6), whereas others said, "I don't use it except for when I need something. … I think it would be nice if I was if I was trained in a routine of maybe how to make it a part of a habit" (Principal 1). From the qualitative data, positive themes emerged around the impact on school improvement and resource allocation along with the desire to see data leveraged for even greater impact.

Qualitative Results for RQ4

Two of the questions asked in the semistructured interview were as follows:

1. How would you describe the impact of data use on your work?
2. How do these data systems affect your job?

From the answers and other responses to open-ended questions on the survey, rich descriptions converged around the ways that digital data tools supported analysis. In addition to the three categories that emerged from RQ2 with regard to using data for comparing, planning, and reporting, this research question allowed full exploration of the impact of data analysis on decision-making in the categories of school improvement and resource allocation as shown in Figure 26. Because comparing, planning, and reporting were covered earlier in RQ2, the focus in

this section is on the impact on decision-making and the areas of resource allocation, school improvement, and underutilization.

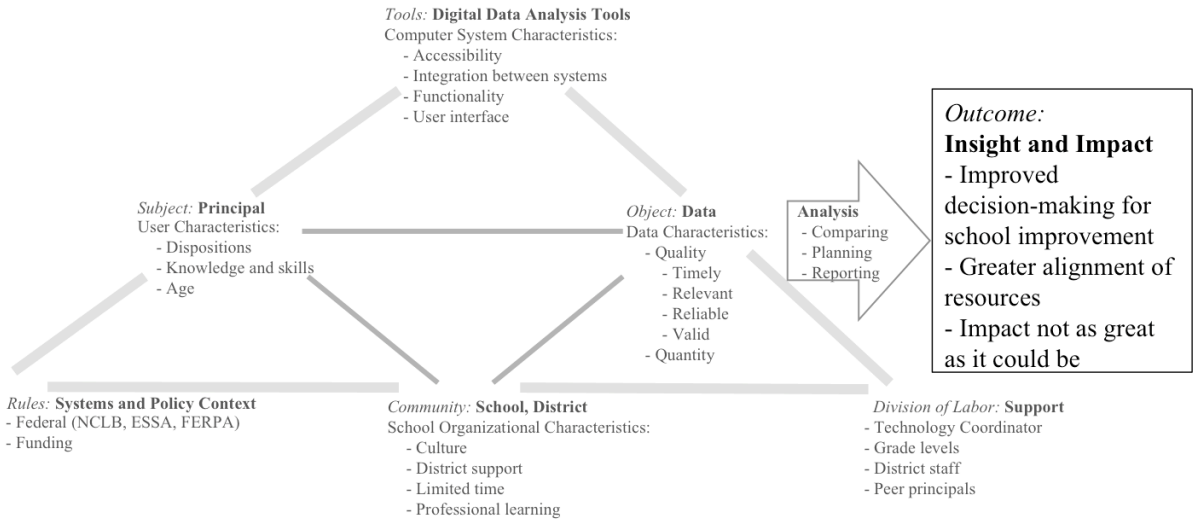

Figure 26. Impact of analysis activities.

Improved decision-making for school improvement. All of the interviewees shared the way data use played an essential role in helping them identify needs that informed various actions. The distinction between data-driven and data-informed was clear in their responses because the data always played a supporting role in the human decision-making necessary for school improvement. One principal said it was analogous to shining a light on reality (Principal 2), and another similarly said it provided a clearer picture of reality:

> I think the data tools gives you a nice little glimpse. I say that it's almost like—like using a microscope. Like using a microscope—I don't want to say to like investigate something … to get a clear picture of what's happening. (Principal 3)

In a trend, principals referred to using data to inform vision as a collective effort using terms like *we* and *our* instead of an individualistic *I* or *mine*. One principal saw data use as analogous to the way indigenous fisherman used nature to inform their actions:

> Our theme for this year is *olelo no'eau*, the Hawaiian saying. And it talks about how the fisherman looks at the clouds, looks at the sky. You know, he uses that information to determine when to fish and where to fish. And when we look at digital tools, it's like the clouds to the fishermen. It's like the tides to the fishermen because it's helping us better understand our students. And see what are the areas in which they're strong that we can leverage and what are the areas in which they're having problems with so we can hopefully remedy and make them stronger readers, stronger mathematicians, stronger writers, in all areas. So that's what we're seeing. (Principal 6)

The digital tools were viewed as a resource to help inform leaders to make better decisions. They also helped leaders bring facts to others while navigating the change process, which could feel emotional. Principal 4 discussed data as a neutral source of information:

> It takes the emotion out of the changes we try to make at our school. We went from a very solid traditional high school into one that meets the needs of our kids and the type of kids that we have. It's been a tough shift. The complex that I'm in—the school that I'm in, is the oldest tenures, has the oldest tenured staff in the state. So, we talk to everybody [who] has at least 15 years of experience or they're very young because there's nobody in between 15 to 30 years or you are very young, so it was a hard staff to move, and even if we showed research we show um ... we use, you know. The demographics and the type of student that we have, even if we give them research-based products and programs. It was

> a hard move for them to change. So the data took some of that emotional changing out of the mix. We could show that—look— these types of kids that we had. And the results that we're getting—this is why we want to make the shift to this type of thing. We tried to move away from the sage on the stage and to using the AVID strategies, getting more student involvement. We did project- based, you know, and luckily, we could collect all of the data that we had, and we could show them that our pedagogy hasn't changed. We're still using the traditional pedagogy and trying to fit these beneficial programs into it. We know we haven't really gone over and changed what we do. We really had been listening to the kids, so it's a tough move and the data has tried, you know, at least we can use it. That way we take the emotion out.

His comments conveyed a reminder that data use is human and inextricably tied to emotional states in which people find themselves in times of change. Many times, as principals discussed the impact of using digital data tools, they talked not only about the impact on them as individuals but also on their entire faculty. As leaders, they were very cognizant of the need for data to inform the broader instructional decisions made on campus, such as what teachers focused on in the classroom or what assessments they needed to give.

Greater alignment of resources. Principals are responsible for managing all the resources at their schools, including personnel, finances, and facilities. As part of the financial planning, principals must consider their schools' unique contexts and challenges. In Principal 2's example below, school personnel reflected on their demographics and had to budget for additional lunch charges that the families might not be able to cover:

> Our parents have a hard time. Their accounts, you know. They don't have money. They can't pay. I mean, then they, you know, they're—then they're on—it goes all the way up to a hundred dollars or even more, so they cannot pay, right? So, we really take a big loss you know, and it's hard to track them down because transient, right? So, a lot of those people are gone.

Although this particular challenge may be unique to Principal 2's school, every principal must consider her or his unique context when crafting the school budget based on the data and information available.

With regard to allocating financial resources to staff, at least half the interviewees spoke of using the digital tools to closely monitor their data to determine whether their enrollment trend had decreased and if so, how such decreases might result in eliminating positions in the future. Comparing enrollment data over multiple years and noting the drop in enrollment, Principal 2 knew she would need to reduce staff. She said, "That's why, you know, for the teachers—I keep telling them that—you know, this is what the future holds for you. … You know, I'm going to have to cut" (Principal 2).

Principal 6 similarly described downloading the enrollment data into spreadsheets to allocate resources with contingency plans:

> You know, for that I more so go on LDS and just look at the spreadsheet, or I ask the SASA to the print off the reports. This is just more for planning purposes. So when we look at our projected and where is there going to be a shortfall. So we look at our scenario. And making sure that I usually like to have an enrollment shortfall for reserve just in case. And then as we lay things out, you know, what is our personnel going to

> cost? What's our casuals, you know? Where is that going to take us? So, I use Numbers more than just for processing the data also for display of data as well. Yeah. I have a spreadsheet.

Principals used the data tools and the data themselves in conjunction with each other. That was the case over many examples of data-informed resource allocations as principals talked about using data to form partnerships with outside entities, using data to decide which resources to purchase, using security data to monitor campus needs, or using data to apply for grants that would impact instructional programming. One example of data-informed resource allocation also surfaced in a high school context, where the principal described using community data and student interest to determine which academy pathways, courses, and instructional focus the school would provide based on the future needs of the community. He said:

> We look at the statistics. We talk to the state to project what types of fields are beneficial to state of Hawai'i, what types of fields are lacking in employees down the road in 5 ... 10 years. We look ahead. We look at that data to project—when these kids get out of college in six or seven years—what types of jobs are people looking for? What types of skills they're looking for? We use all of that research and data to look into our academies, so not just what we offer as courses. We also look at each academy—equal focus is given to the content and the skills. So, there are certain sets of skills these kids are going to need in seven years when they get out that we want to make sure that we have it in all of the academies. The ability to communicate the ability to think, you know, think on your own and be creative. Good public speakers, you know, things like that. They would carry themselves well. Adjust in a tough situation. Have some—what's that word we use? …

Grit. So, we look at those things and, you know, make sure that we have all of that in our instruction. (Principal 4)

External community partnerships were also formed by principals who deeply understood their data and were able to advocate for additional resources aligned to their needs. Principal 6 commented:

> We formed a partnership with Kamehameha schools for them to give us training on the benchmark assessment system BAS Fountas and Pinnell because when we look at the kids who struggle with reading, what we have found by looking at our data [is] that we have kids who can read fluently. And yet they struggle with comprehension. And so it's always—it's been right there in front of us in terms of the fact that we're not focusing on comprehension and not connecting fluency to comprehension. But we've—we've been blindsided by it because I think everyone has been compartmentalizing in terms of—okay, it's my job to teach fluency in grades K, 1, 2, and so that's all I'm going to teach. You know, I'm not thinking about—okay, are they really understanding? Or are they just reading fast? Which is what they were doing. So, I have kids at fifth grade who have high fluency rates. You know, they can read really quickly and fluently, but they don't attend to punctuation or vary up their intonation. And then we ask them questions in terms of what they read. Beyond recall, they have no clue. And so in doing that deeper analysis and using the benchmark assessment system, we have a better sense now as to where are they falling, where are they struggling. Yeah, so in terms of the value that we're getting, it's equivalent to about maybe six or 7,000 dollars for professional development that we're receiving.

In summary, numerous examples showed the positive impact that data analysis supported by robust tools has had on the work of the principal, but a general perception that greater impact yet to be seen was clearly present.

Impact not as great as it could be. A major theme emerged in which principals thought their data and data tools had been underutilized. One principal admitted that practice surrounding data use was not where he had hoped it would be:

> I'm not afraid to say or ashamed to say that it is not used to the capacity for which it should be. … This is one of the greatest weaknesses of our school, and our greatest challenge is the use of data to make informed decisions. And so, you know, I've been fighting kind of a cultural battle at this school for the last four years. You know, since I got here actually in our area, we're finally kind of changing. Our climate has really changed as far as like safety on campus making this a welcoming place and trying to build bridges between elementary schools. A lot of—a lot of my focus and energy has been put on getting our campus to be a normal middle school campus. (Principal 3)

Another shared how the teachers were unable to make the connections among the data they studied, the interventions they tried, and the ultimate outcomes they intended to impact. Principal 2 stated:

> They gotta take the SBA, look at Level 1. Lucky if you've got a Level 2, you know, for ELA and for math. But they're not even looking at that. And so this is why we have these enabling activities. They don't make the connection. Okay? They're not making the connection. So I said, you know, we've got to look. We go through the motions and data teams, but are you really changing your instruction? You said, "What are you going to

use?" A graphic organizer? Is the graphic organizer really working? Is that making a difference? Because the bottom line in reading is that they got to be able to comprehend. So when you see the graphic organizer, they are using it as note taking; but I mean, is that helping them to be able to read, and understand, and answer the questions in SBA? They are not making the connections.

The true impact of data use to generate improvement seemed to be a topic with which almost every principal actively wrestled. One said:

> Part of our conversation is it's not [generating improvement]. The question we're having after WASC—and we were at the end of the year as an ART team, ILT team, we're working on was we don't know that it's necessarily that we don't have enough data. … The million-dollar question always is—and based on the data—We did what? I think that around the whole topic of data as a school is as one of our questions because, you know, as we say, elementary—you have 23 students, 22 students, now you have STAR, you have all these sources. But really the million-dollar thing is how do you use what you know about that child to tomorrow plan instruction for him or her? That is at the level that differentiates. That makes a difference, right? And I think sometimes we hide behind, well. ... If I had more data then I would—and data doesn't lead you to better strategy. Data doesn't change any of you're not planning, or you're not researching, or you're not, ... you know, the next pieces of that cycle. So, I think for us as a school and structurally around data the conversation, we're moving towards. (Principal 1)

The idea of untapped potential seems like a systemic problem, not merely at the school level but also at the district level. This comment from Principal 4 demonstrated that sentiment:

> I think they talk about it a lot, but it's more about collection and identifying. I don't know if they're really checking to see if we're really using the data to actually make impact and make change. We all use data. But is it really being used to change what needs to be changed or is it just we're using data to monitor how well we doing certain things? I look at it to make sure it's a change and creates impact for kids. And that's why I haven't found stuff that sometimes satisfies myself as a principal.

The findings showed that data use was seen as impactful, but users still held out hope for unlocking even greater impact.

Summary

This chapter included findings from this mixed methods study on the experiences of principals using data analysis tools in Hawai‘i. Four research questions were posed in order to better understand the experience of principals using digital tools to engage in data analysis:

RQ1. What types of data and data analytic tools do principals use?

RQ2. How do principals use data analytic tools?

RQ3. What factors influence principals' use of data analytic tools?

RQ4. How do principals describe the impact of data analytic tools on their work?

Results summarized in this chapter emerged from multiple data sources. A visual representation of the data from Phase 1 appears in Figure 27. A visual representation of the findings from Phase 2 appears in Figure 28, and visual representation of the combined data appears in Figure 29. To answer the first question, principals reported using data they collected, such as teacher

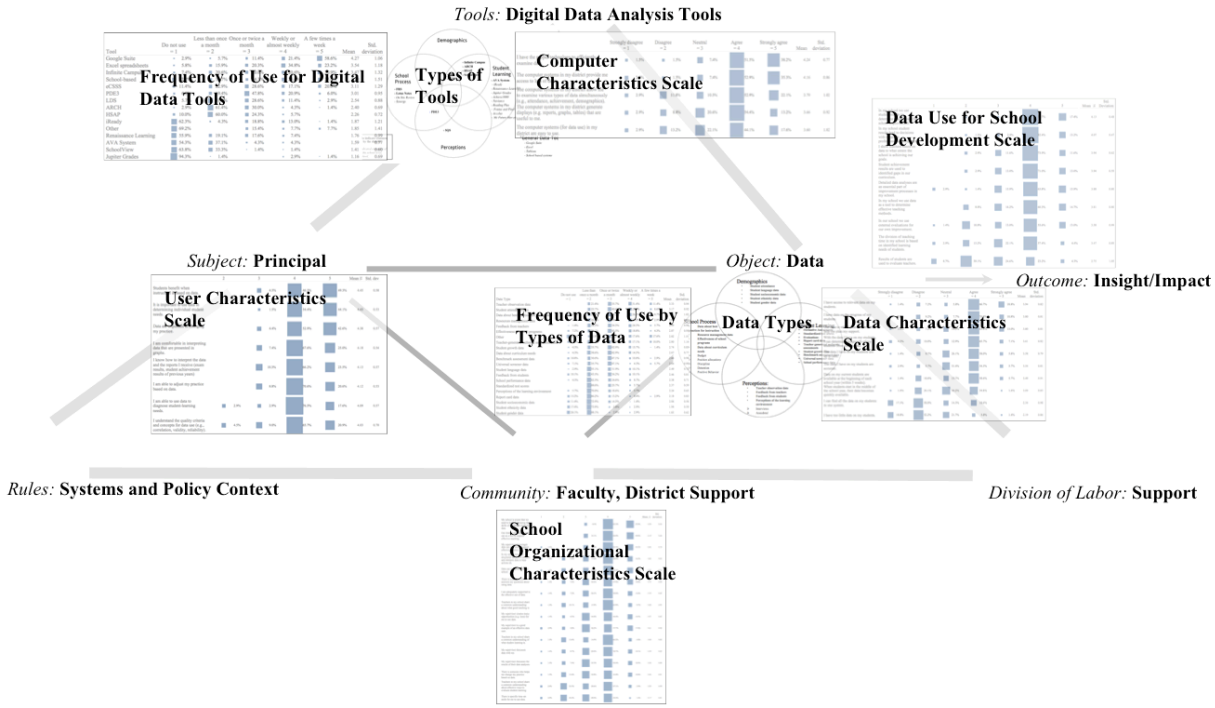

Figure 27. Visual representation of the data from Phase 1.

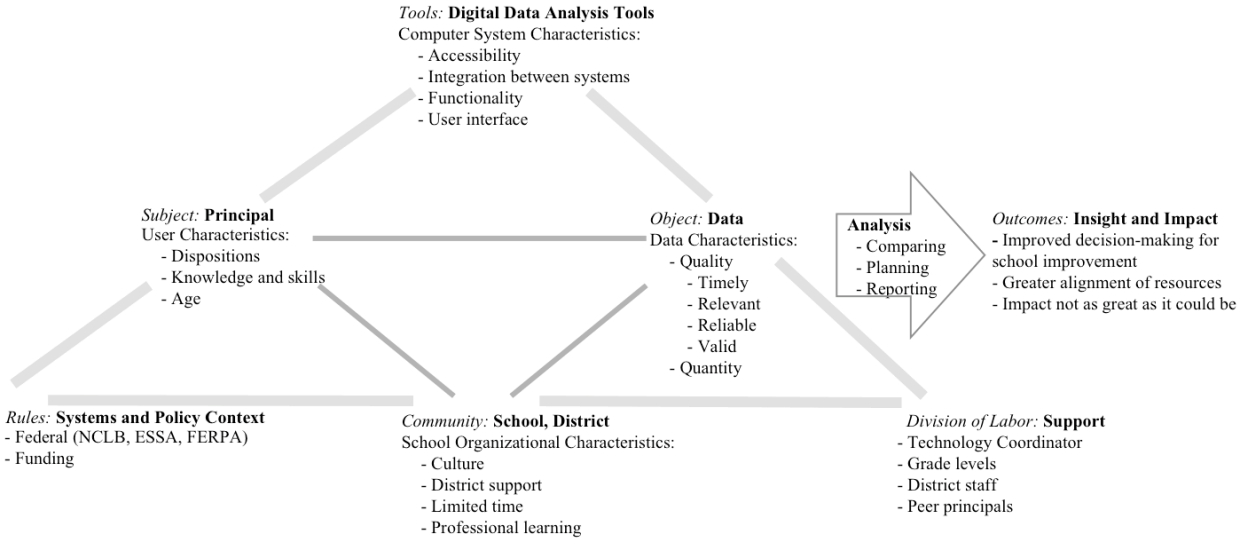

Figure 28. Visual representation of the findings from Phase 2.

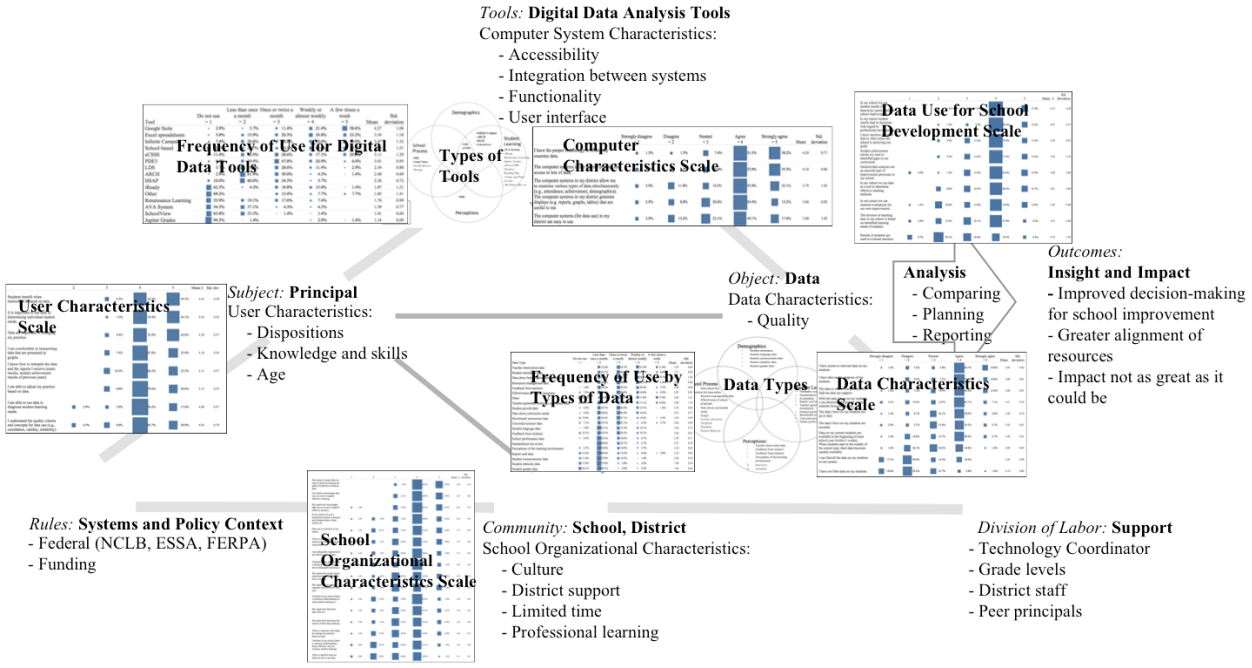

Figure 29. Visual representation of the combined data from Phase 1 and Phase 2.

observation data and data that was relevant on a daily basis, such as student attendance data, most frequently. Data that provided information about resource allocations, accountability and performance, or anecdotal feedback were typically used once a month or less followed by student demographic data, which was used the least. Google Suite, a free tool that the district had not yet formally supported, was reported to be used most frequently several times per week. Excel spreadsheets were used next most frequently followed by a number of district-supported tools that performed specific functions, followed by tools principals individually purchased, such as Jupiter Grades, or created in house.

To answer the second question, the manner in which principals used the tools for various school development efforts were explained, including making comparisons, planning, and

reporting. Data were used to compare time intervals, schools, teachers, specific groups of students, and programs. The main categories that emerged under data informed planning included academic planning, goal setting, budgeting, staffing decisions, and teacher support.

To answer the third question, factors that influenced their use were summarized, which included data characteristics, such as quality and quantity; user characteristics, such as disposition and skills; school organizational characteristics, such as professional learning and time; and computer system characteristics, such as integration, accessibility, user interface, and functionality. To answer the last question, participants described the impact of data analysis tools on their work as an integral part of what they do while recognizing they were underutilized. In the next chapter, the meaning of the results appears in conjunction with the related literature and conceptual framework.

CHAPTER 5. DISCUSSION

The purpose of this mixed methods study was to understand the experience of principals using digital data tools in a K–12 system. I sought to strengthen my understanding of their experience through online surveys, observations, semistructured interviews, and think-aloud protocols. Specifically, I hoped to find out what data and tools they used, how they used them, and how they described their impact on their work. Using both qualitative and quantitative analysis software, I identified several broad categories for each research question. In this chapter, I advance the discussion of the findings and implications in relation to the conceptual framework and existing literature. This chapter concludes with a discussion of the limitations of the study, areas for future research, and a brief summary.

Discussion of Findings

One of the major findings in this study is that principals in the HIDOE believed that the ultimate goal of gaining insight from data use had not reached its fullest potential. Similar to principals around the world (Schildkamp & Kuiper, 2010), HIDOE principals shared that the use of data to inform decision is one of their greatest challenges (Principal 3). As in other studies, the mere availability of data and tools has not guarantee use (Kowalski & Lasley, 2009) or changes in practice (Wayman & Stringfield, 2006), and the factors impacting data use have remained complex and numerous. Activity theory framework was used in this study to provide a structure for examining relationships among (a) the subject, principals; (b) the object, data; and (c) the school community. The findings are discussed in two parts: first, in terms of the insight that can be gained by considering the role of data analysis tools in mediating the relationship between the principals and the data; and second, in terms of the insight that can be gained by considering the

other factors in the social context that may have impacted principals' data analysis activity. The alignments and tensions in the activity system as a whole can be useful for educators, policy makers, and designers seeking to identify challenges and improve the current reality.

The Mediating Role of Data Analysis Tools

In considering the ways that data analysis tools shaped the experience of principals interacting with data, I drew upon the field of user experience (UX), which includes the extent to which technology is both useful and usable, each of which merits its own discussion in light of the findings (Blythe et al., 2006). The visual below, Figure 30, organizes the main challenges users experienced in interactions with digital data analysis tools.

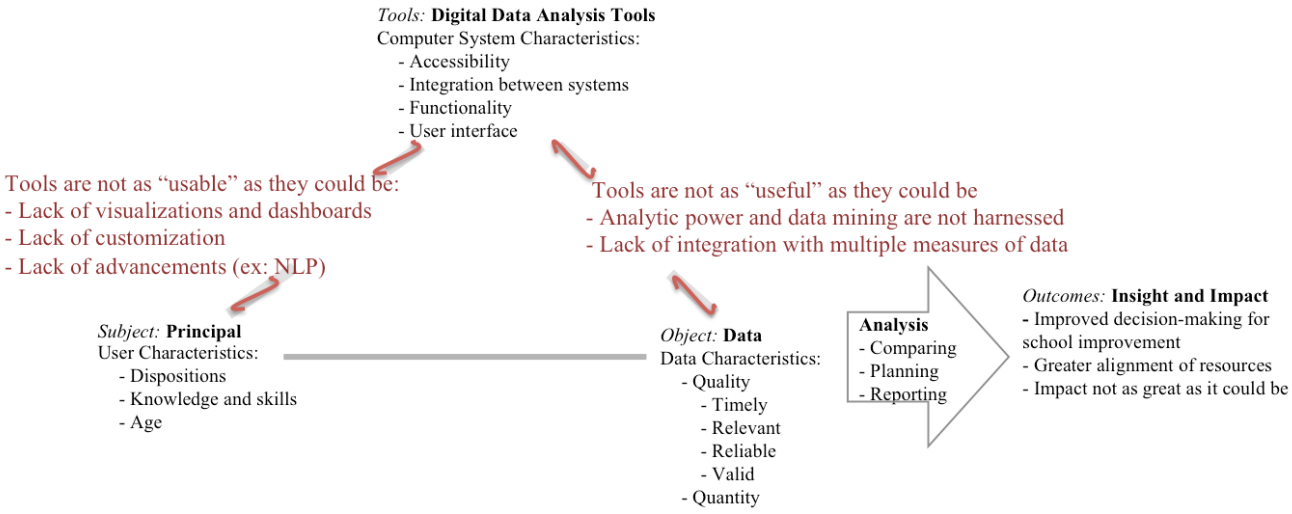

Figure 30. User experience challenges with the tools.

District-sponsored data analysis tools are not as useful as they could be. As principals sought insight from their data, they often interacted with data and data analysis tools that were not as useful as they could have been. The tools they interacted with did not harness the analytic power that would be expected in light of the national trends surrounding educational data mining (EDM) that uses machine processing power to detect patterns in large data sets (Sin

& Muthu, 2015). The findings in this study did not show any evidence of EDM or predictive analytic tools. Large volumes of data were available, but the tools provided included mostly static and descriptive reports that failed to harness the analytic power of contemporary data processing.

Issues with the data themselves also impacted their usefulness. Previous researchers have clearly documented the need for data to be available in a timely manner, of high quality, up to date, and accurate if they are to be useful (Schildkamp, personal communication, October 26, 2017). The findings in this study show that principals perceived those qualities to be lacking. The Data Characteristics Scale had the lowest overall mean of the four scales from the online survey. Comments from the interviews included terms like "lagging data" and "autopsy data" as principals described how data were less useful because they were not as timely or relevant as they would have liked. For over a decade, research has shown that principals have identified challenges with excessive raw data, inadequate technology, lack of coordination among data sources, and lack of timely data (Reeves & Burt, 2006); the findings in this study show that those issues remain persistent. Disparate data collection has been well documented over time (Wayman et al., 2010) and remains a major challenge for principals who do not have the time or technical skills to merge data sources to conduct the type of analysis they desire. The gap between what educators should analyze in theory and what they are actually able to do in practice is worth exploring further.

In theory, educators should use multiple measures of data, cross-analyzing those data types. Bernhardt's (2018) model for intersecting the four types of data—demographic, school process, perceptions, and student learning data—showed 13 different regions of analysis.

However, an adapted version of Bernhardt's model was needed with a slight modification to switch the positions of the student learning and perceptual measures because a number of tools that did not fit into the original model. Figure 31 shows how I adapted the visual of Multiple Measures in order to place student learning measures and demographic measures next to each other so that their overlapping region shows the two-way intersection that supports information about differences in the way groups of students perform.

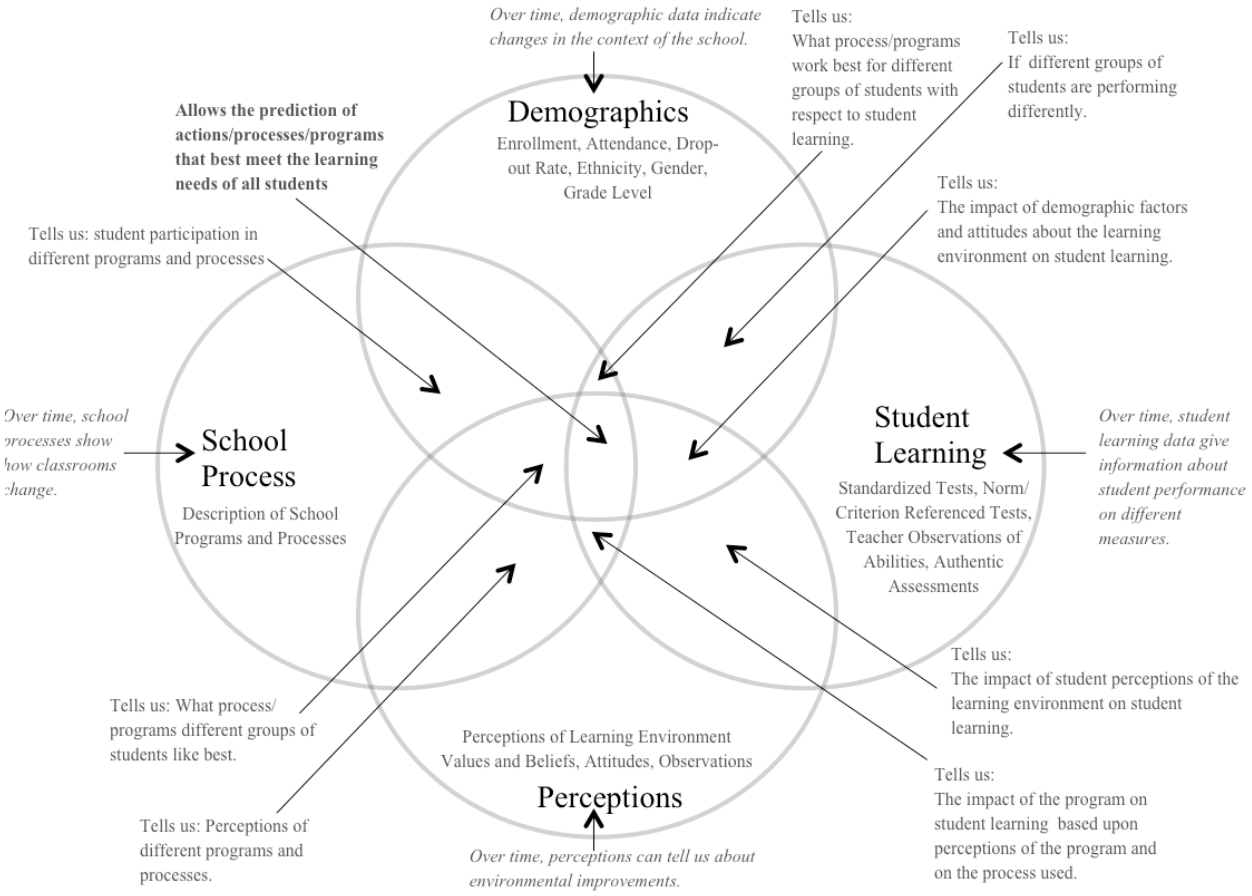

Figure 31. Adapted visual for Multiple Measures.

Figure 32 shows the alignment of tools used by principals compared to the ideal standard for using multiple measures of data. In comparing the theoretical model with the reality of the

tools used, color illuminates at least five regions of cross-analysis that are unsupported by digital tools. Most significantly lacking are tools to measure and analyze perceptual and school process data. Although principals have access to disparate data, they lack tools that integrate three to four data types in a way that would increase their ability to analyze the data for actionable insights.

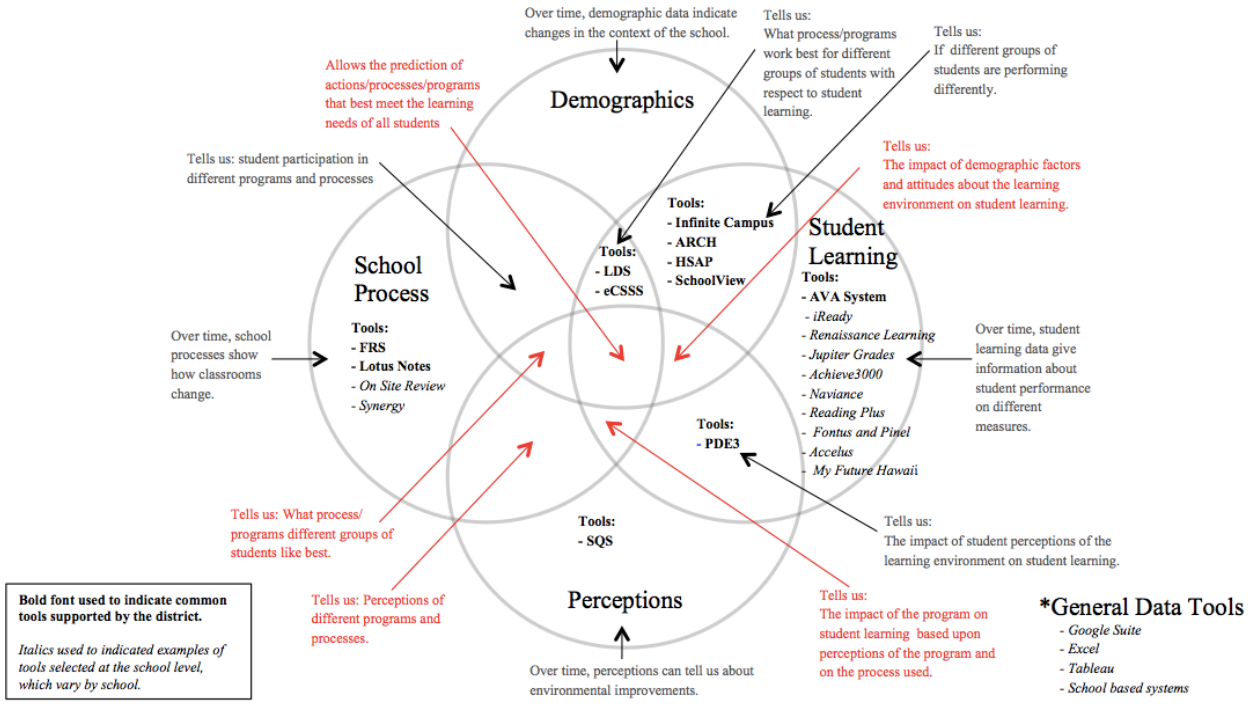

Figure 32. Theory–practice gap comparing the theory behind using multiple measures of data to the reality of the tools that principals use.

Adding in the general data tools described by principals in this study has resulted in increased potential for integrating measures; however, each of those general platforms for working with data requires users to collect and connect their own data. Google, Excel, Tableau, and some of the tools schools have created on their own have capability that "allows the prediction of actions/processes/programs that best meet the learning needs of all students" (Bernhardt, 2013b), but this study has provided no evidence that principals used those tools for

that type of predictive analysis. This can be explained in part because tools unsupported by the district cannot sync with the existing data warehouses and would thus require additional work for principals who wanted to conduct integrated analysis. The majority of tools unsupported by the district were limited in scope, not only by the product design but also by the privacy permission they can obtain. Most digital products purchased by schools do not include permission to integrate with other types of data owned by the district, such as student demographic data. The trend among principals is to invest in more student learning measures like universal screeners (iReady and Renaissance Learning), online gradebooks (Jupiter Grades), and other subscription services that operate like stand-alone systems.

In the era of overemphasis on accountability, one might expect funding and resources to be prioritized for student learning data. Tools reflect the intent of creators motivated to meet certain needs, and clearly, the need has remained focused on student learning (Kaptelinin & Nardi, 2006). In theory, analyzing multiple measures could help school leaders understand what programs contribute to achievement results with different students, but in practice it would be difficult for school principals to conduct such analysis, given the current limitation of the tools. When looking at all the tools used by principals, the underrepresentation of tools to measure and analyze perceptual and school process data is clear.

District-sponsored data analysis tools are not as usable as they could be. Research on user-centered design shows that well-designed objects are easy to interpret and understand, but poorly designed objects are frustrating (Norman, 1988). I observed over half the users in a state of frustration during the think-alouds, struggling with everything from logging in to pulling reports to locating their files. I recall watching a principal on the most widely used system

supported by the district, the Longitudinal Data System (LDS). She logged in to a home screen entirely filled with text, and in attempting to access her school's data, she had to click through multiple options to verify her school location. When she was unsuccessful at pulling the report, she was not given a detailed error message. She was left feeling defeated and lacked the confidence to move forward. Nielsen (1993) defined five usability goals in his seminal user studies: learnability, efficiency, memorability, error-forgiveness, and satisfaction. Principals observed in this study did not achieve those goals. In that example, the tool appeared to be efficient, based on the number of clicks required of the user; and it was not error-forgiving with the general error message. The design of the tools must intentionally anticipate the wide range of users who access the system. Ideally, every platform would be designed in such a way that a variety of users would want to use it because it is valued for its beauty and usability, which are two correlated qualities (Tractinsky et al., 2000).

Data visualizations help process information more effectively when using visual elements, such as colors, shapes, and distance, to illuminate patterns in the data (Mackinlay, 2009). By drawing attention to key information and reducing extraneous noise, the design of data visualizations affects humans' ability to interpret the data presented and impacts usability (Sanjines, 2018). Other industries have shown us that at the core of a rich visual analysis cycle lies an empowered user who both creates visualizations and changes them (Morton et al., 2012). Technology advancements have empowered users who had typically been consumers of preset data reports to lead their own inquiries (Azzam et al., 2013; Kung, 2015); however, those advancements have been slow to make their way into the hands of school leaders. The findings in this study show that principals remain primarily consumers of preset data reports.

Zhang et al. (2012) found that visual analysis tools generally supported the following: (a) exploration that allows users to generate and verify hypotheses; (b) dashboards that support interactions such as selection and filtering; (c) reporting of static summaries of data; and (d) alerting with an automatic notification when data sources reach predefined parameters. The tools in this study can be best described as the third item: reporting of static summaries of data. No evidence of automatic notifications when data sources reached predefined parameters was found to be available to principals, yet the usefulness of such capabilities is apparent. Some studies have shown that real-time data dashboards that bring together multiple measures can be helpful to educators in quickly diagnosing what is and is not working for students (Darling-Hammond et al., 2016). Other studies have shown, however, that the tools used by principals generally do not follow basic design principles and resemble something closer to static reporting than a true dashboard (Marker, 2016). Countless references were made to user frustration in this study, for example, "The data is there, though at times hard to access and organize" (Open-Ended Survey Respondent 1). Perhaps a dashboard that followed current UX tenets and was designed for a wide range of principals' needs could support more visual processing and help alleviate some of that frustration.

UX metrics depend on the goal of the product (Hassenzahl & Tractinsky, 2006), and the ultimate goal of visualization is insight. From the surveys and interviews a picture has emerged with regard to the tools principals used during this study and the insight they were able to gain, at times suggesting a mismatch between designers' intentions and users' experience. For example, when a principal said, "I think at first, I thought that it was going to give me access to [a] much more in-depth look at student" (Principal 1), the point was that the experience fell short of their

initial expectation. In the era of intuitive technologies like smartphones, perhaps principals have grown accustomed to a certain level of ease of use not found in their data platforms. One key suggestion made by an interviewee derived from his desire to have a data analysis tool with natural language processing (NLP). Novice data users often wish to explore data but are limited by their inability to formulate their questions in terms of tool operations (Setlur et al., 2016). Interfaces accepting questions in the format of a user's natural language for querying and discovering data have generated more interest as those tools improve (Setlur et al., 2016). Natural language technology, such as IBM's Watson Analytics or Apple's Siri takes questions formatted in various forms of plain English and returns answers (Setlur et al., 2016). By examining the types of queries, the types of ambiguities in queries, and the flow of queries, technological improvements have been made so that users can have a dialogue with these tools by asking questions without needing to know mathematical functions or precise terms (Setlur et al., 2016). When it comes to interacting with data visualizations, studies have shown that even when users know what issues they want to explore with their data, they may have difficulty specifying the correct details or directing a system to produce the right charts (Setlur et al., 2016). One promising platform, Eviza, can take a user's query like "find large earthquakes near California" and intelligently handle the ambiguous terms *large* and *near* by associating the descriptors to attributes in the data set such as *magnitude* and *distance*. The Tableau platform now has a tool called Ask Data, which can interpret the intent behind vague questions to produce visual results. An application of such tools in education might entail a principal who asks for a query on the "top student" or "highest performer" or "maximum score," and the system is flexible enough to interpret a wide range of terms to query the data. The dream of having a

natural conversation with his data, shared by one principal, is a dream realized in other industries and would certainly benefit school leaders who are not data analysts by training.

The district should align its support for tools that meet the needs of users or create some flexibility in their tools so they can customize their experience to meet their own needs. A prime example appeared in the online survey, where principals said they used teacher observation data most frequently with 43% using that data type on a weekly basis; yet only 27% said they use the PDE^3 platform supported by the district for collecting and analyzing observation data on a weekly basis. The disconnect between the need and the support became apparent in the interviews when principals indicated that informal observation data were more relevant for them, but at the time the district did not support any tools to collect informal observation data. Thus, most principals used Google Suite tools set up by their school sites. This example shows that the flexibility and empowerment inherent in Google tools allowed users to collect the data they needed and used most frequently regardless of what the platform designer had determined they needed. The findings from this study confirm an apparent trend found by other researchers as well that educators desire greater customization and functionality in their data platforms and have for over a decade (Wayman & Stringfield, 2006).

In the activity theory framework, activity is a key source of development for both the obejct and the subject (Kaptelinin & Nardi, 2006). Through activity, mutual transformation and development take place as humans shape the tools and the tools shape them. Evidence arose in the context of this study that the tools have developed over time based on users' input (Bush et al., 2014); tools may also have established certain mindsets in the users. With tools that are not as usable or useful as they could be, users may have developed an avoidant mindest as

demonstrated by the principal who described data anlaysis as speed dating because it has not been very reliable in the past. Others have internalized their frustrations in a way that has shaped their own identy to the point that they have considered themselves not particularly tech savvy. They have developed a consumer mindset when it comes to pulling reports because they have not had access to tools that allow them to customize or create based on their unique needs. They may not see the collaborative possibilities for using digital data tools because the tools themselves have not offered such capabilities. The mediated relationship among the subject, the principal, and the object—the data—can be further understood by considering the elements of the community.

The System as a Whole

Because all activity is situated in a larger social context, looking at the system as a whole is beneficial in identifying factors impacting principals' use of data and digital data tools. Making sense of the related factors in the structural model of activity theory is helpful in identifying tensions among the characteristics of the system (Gedera & Williams, 2016). Although the first part of the discussion of findings has focused on the mediating role of the tools, focusing on such technical issues alone can obscure the importance of the "people problems" associated with data systems (Cho & Wayman, 2014). The following sections explore the tensions identified by examining the element of community, visualized in Figure 33, along with the mediated relationships of rules and division of labor.

Community of faculty and district. A principals' broader community consists of school-level faculty, a geographic Complex Area, and a state-wide school district nested within a national educational structure. Survey responses on the School Organization Characteristics

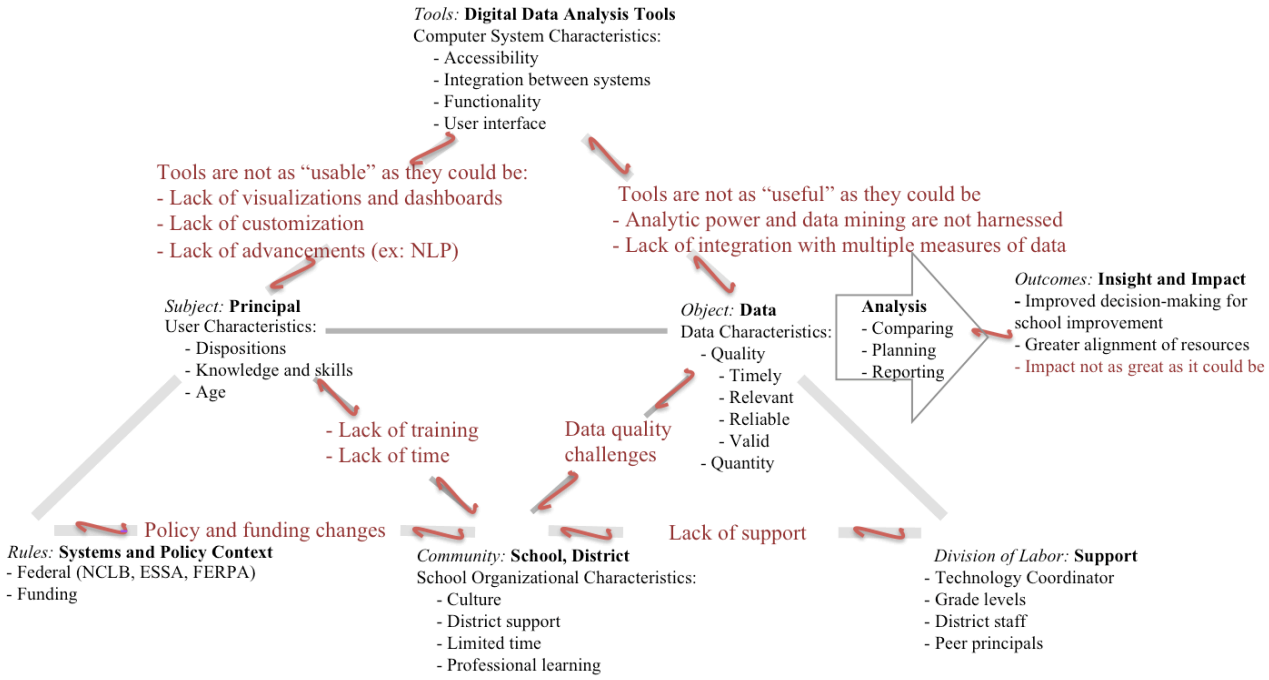

Figure 33. Tensions in the activity system identified by tilde mark.

Scale indicated a shared belief in the value of data use, yet that did not seem to translate into some of the organizational structures needed to support the practice. Only 45% of principals agreed or strongly agreed that a specific time had been set aside for them to use data. Without time built in, all interviewees said they engaged in data analysis outside the workday, early in the morning or late at night. Lack of dedicated time for data analysis amid administrator overload was a problem identified in earlier studies (Reeves & Burt, 2006), but the problem has not been solved.

Principals in this study expressed a desire for more training to enhance their data literacy skills as well as their proficiency with technology. One of the key qualities found in the literature on high-quality professional development involved working on a practice over a sustained period of time, specifically an average of 49 hours to show positive effects on student achievement

(Darling-Hammond et al., 2016). One of the interviewees in this study described a skill in which he had become proficient after the district provided him with over 30 hours of training and then compared that to the lack of training he received on the district's data analysis platforms and the lack of confidence he had as a result. This sentiment was echoed repeatedly as principals said they wanted to learn how to use data effectively and they believed the tools should help more than they did. Professional development organized by the central office was needed (Wayman et al., 2012). Principals benefited from participating in educational technology conferences to further their learning but noted that district policies limited those opportunities as a result of travel restrictions.

In addition to creating structural support for the time and training needed for principals to become effective users of technology and data, the district also played a key role in setting up the support structures for the data themselves. The district typically created and maintained the data warehouses and set the standards for data quality as well as data governance. The data quality issues experienced by the principals in this study were generally not ones that they were in a position to address. In this mediated relationship, principals remained dependent on the district to seek improvements that would result in more timely, relevant, reliable, and valid data. The principals and district leadership must work hand in hand to assure alignment between district priorities and the type of data available. For example, student voice was named as a district priority; however, 10% of principals in this study reported never using feedback from students at all. Minimal tools were supported at schools to capture and report student feedback data, and minimal training had been provided as already noted. Misalignment among district priorities, principals' reality, and provided resources is an important finding of this study. For example,

Google Suite was the most frequently used tool with a total of 80% of principals using it a least once a week despite lack of support by the district. Given the important role the community plays in the activity system, the principals could be more successful with district support.

Division of labor. Most interviewees acknowledged the help they received in data analysis activities from Complex Area support as well as school-level support staff like technology coordinators and curriculum coordinators; however, despite the handful of examples in which division of labor existed to help principals, the overwhelming trend was a perceived lack of support. Some principals lamented their inability to afford a technology coordinator to help them with the current technologies; others saw the lack of support as a barrier to moving forward with more advanced technologies. For example, one interviewee desired a more complex database system but foresaw an issue with the support it would require. He said, "I know it's out there, but they're expensive typically; and you need someone who can spend a dedicated amount of time to create it" (Principal 6).

Without dedicated staff at the school level and Complex Area for data support, no consistency in support staff emerged across geographic regions. This lack of support impacted data analysis activity as well as the development of users' knowledge and skill level. No mention was made of peer principals working together in formal learning communities or coordinated efforts to learn from one another. One interviewee even described himself a "self-made man" (Principal 3) when it came to learning about technology in general while other principals gave examples of specific people who had helped them. Given the perceived inconsistencies, the district may benefit from considering the establishment of consistent professional collegial communities among principals to support their ongoing learning (Darling-Hammond et al.,

2016). Other studies have also shown that dedicated data coaches can serve as an effective support structure to build capacity for data use, but that form of support did not seem to be available to participants in this study (Lachat & Smith, 2005).

Systems and policy context. The types of data and the types of data analysis tools principals use have been shaped by the larger accountability culture that has defined the recent educational landscape in America (Datnow & Park, 2014; Ehlert et al., 2014; Murray, 2014). Findings in this study align with the following sentiment in the literature that although accountability is meant to contribute to school improvement, tensions and conflicts often arise between these purposes (Hargreaves, Braun, & Gebhardt, 2013). The "Every Student Succeeds Act" (ESSA) places an emphasis on disaggregating data by the following demographic subgroups: major racial groups, economically disadvantaged, disabilities, English proficiency status, gender, and migrant status (Sharp, 2016). In light of that policy, a surprising 17.4% of principals in this study reported that they did not use ethnicity data at all, and 11% did not use socioeconomic data. Perhaps this occurred because the tools they used more regularly, for example, universal screeners or Google Suite, were not integrated with that type of demographic data. But this is an important policy–practice gap to examine further because federal funds were used to establish a Longitudinal Data System with a goal of evaluating the effectiveness of instructional approaches for educating various types of students (U.S. Department of Education, 2009, p. 8). Advancing an agenda that increases equity will be difficult if principals are not regularly informed of student performance gaps on a series of measures. In light of the disproportional investment in tools that measure student learning, an interesting consideration might be the subsequent impact if guidelines for the Race to the Top funds had required funding

spent on systems with a more balanced representation of a variety of types of data instead of only demographic and student learning data. In some ways, ESSA has provided a new opportunity for districts to view students and schools more holistically, but in order to make that shift, district leaders need to think more creatively about developing new measures and interventions that further equity goals (Darling-Hammond et al., 2016). The values articulated throughout the broader educational community in the form of policies, accountability systems, funding, and other resources have a profound impact on practices at the school level.

Limitations of the Study

Answering all the questions that arose related to the activity system of focus, the mediating tools, and their social context was beyond the scope of this study. The study was limited by the assumptions held, the bounded scope of the study, and my delimiting choices.

This study relied heavily on the perceptions of the principals themselves, operating on the assumption that participants answered survey and interview questions factually. I assured that participants understood the efforts in place to guarantee confidentiality and security so that principals felt comfortable answering honestly, but I was also aware that responses may not entirely reflect reality. Some differences may exist between the perceptions of participant and consciousness of their actions as opposed to their actual actions in an everyday setting. This can be compounded by the fact that surveys have limited response categories, thereby limiting the range of responses even with additional opportunities for them to express themselves in open-ended questions.

This study was limited by a variety of parameters in the study design, most notably the limited geographic scope, bound to the state of Hawai‘i; thus, it may be less generalizable to

other geographic locations with a different context. The purpose of this study was to understand the experiences of K–12 public school principals but not the experiences of leaders in private schools, charter schools, or higher education settings. It was also time-bound by collecting data over a six-month period, which limited the breadth and extensity of data collection. There were external factors at the time, such as a volcanic eruption on one of the islands, that may have may have reduced the number of participants and perhaps resulted in biased responses. People with perceived time constraints and other stressors may have been less likely to respond to surveys, and people who are less comfortable with technology may not have been inclined to take surveys online, thus limiting the pool of participants for both Phase 1 and Phase 2.

In light of the inability to consider all possible variables, I made delimiting choices when designing the study. Deciding to look at data analysis tools as a whole as opposed to specific tools yielded broader recommendations but describing the nebulous user experience was problematic. Studying specific tools one at a time would have afforded the opportunity to do a more evaluative study of UX design principles for each platform but would have exceeded the time and resources available in for this study. In selecting principals as the focus population, this study differs from the larger body of research focused on teachers' data use for instruction but adds to the smaller research interest on principals as key leaders in data use. Focus on principals necessarily excluded the experiences of others in related roles, such as superintendents, teachers, support staff, and even software designers.

As unforeseen challenges arose throughout the study, I had to make small decisions about how to move forward in way that adhered to the purpose of the study. For example, when two females from the original list of selected participants for Phase 2 were unresponsive, the

researcher decided to select two additional participants who met the other prioritized user characteristics of diversity in user confidence level and geographic location, resulting an unequal representation of females in the final interview phase. That decision was made because the purpose of the study was to understand principals' experiences as users of technology and not to cover gender differences.

Implications for Theory

This study was focused on investigating the experiences of principals as users of digital data tools. Its findings can have implications for the development of theory as well as for tool designers. One contribution of this study was the creation of a pictorial representation of principals' data analysis activity showing the interplay of related factors (Figure 10). Using the structure of the activity theory framework (Cole & Engeström, 1993) made possible the conceptualization of the relationships that emerged in relation to data use in schools while considering the important mediating role of the tools themselves. Other frameworks, such as Schildkamp's data use framework (2012), have provided for consideration of enablers and barriers of data use to include organization, data, and users but have missed technology as a significant factor. The findings from this study confirmed technology as a major factor influencing educational data use. The use of the activity theory framework to produce a pictorial representation of factors related to principals' data analysis activity facilitated the creation of a visual representation of tensions in the system as well.

Activity theory continues to provide a strong theoretical account as to the mediating power of tools in human activity. Although activity theory has been applied to study other technologies in the past, I found no other study in the literature that focused on principals who

used digital data tools in the context of activity theory framework. This study adds to the growing body of research that confirms the usefulness of activity theory to guide the development of research questions, conceptualize relationships between factors, and identify tensions in an educational setting. By simultaneously drawing from the field of UX, I was able to use the activity theory framework in this study to organize factors that impacted users in a way that can be useful to others interested in linking the two fields of study. Theories evolve in communities as concepts are shared and compared in new contexts, ideas are abstracted, and language is generalized (Kaptelinin & Nardi, 2006).

This study extended the use of Bernhardt's (2013b) framework for Multiple Measures of Data, which was initially designed as a means for categorizing different types of data. The adaptations I made to the Venn diagram changed the position of two circles, which also changed two of the 13 regions for intersectional analysis. These changes made possible the organization of the data analysis tools used in practice, particularly those that intersected only demographic and student learning data. This adaptation warrants more research in order to further explore its impact and usefulness. In theory, educational leaders should intersect all four data types in order to engage in deeper analysis, but the findings from this study showed that this level of analysis is not currently supported by the tools that principals possessed. Without the adaptation of Bernhardt's (2013b) framework for Multiple Measures of Data, the imbalanced representation of data types and data tools may not have been identified. The refinement of theoretical frameworks can support productive cooperation between researchers and designers by structuring ways to break down large problems into smaller, more manageable subproblems (Kaptelinin & Nardi, 2006).

Implications for Designers

For each of the tensions identified in this study, designers can explore tool enhancement to support solutions. For example, users stated that they lacked access to training, so perhaps designers can address the need by embedding training modules in the tools themselves for ease of access. Because users were challenged by a lack of time to engage in data analysis activities, designers can enhance time-saving features, such as push notifications that would send principals data alerts when key thresholds are met instead of waiting for the principal to log in. Specific recommendations by participants in this study may also have implications for designers, such as the ability to interact with natural language querying much like users already do with other technologies that would empower them to converse with their data while reducing technical barriers. Because lack of integration among tools was a major barrier to use, designers could build empathy for end users and create technical solutions to integrate tools adhering to data interoperability standards. Principals want modernized data systems that include the capability to customize dashboards to fit their unique needs and update in real time. In designing for future principals, a point of crucial consideration is that schools will become more digitally connected and generate ever greater amounts of data that will require processing.

The findings in this study point to the tremendous importance of user experience. A need exists for designers of data platforms to work with principals directly with an iterative design mindset so that the tools continue to develop as data sources change, user needs change, research expands, and theories are updated. User-centered products are enhanced by user research based on user narratives and lived experiences. As designers build and evaluate working prototypes, it is important for users to test them in a natural setting. User feedback on the utility of the tools as

well as the aesthetics is important to understanding why, what, and how the users interact with each feature. Users should be interviewed regularly about their user experiences, and digital log files should be reviewed for use patterns and errors.

One can expect that these tools will always be used by people possessing a wide variety of dispositions, skills, and knowledge and that the designers' responsibility is to intentionally design for this variability. Specific attention must be given to understanding the dynamics of visualization platforms that successfully support a wide variety of users in making sense of their data and gaining actionable insights so that those features can be replicated by other platforms. Users will benefit from tools that are informed by evidence-based practices and current theories.

Implications for Practice

In addition to the implications for the development of theory and tools, the findings from this study have practical implications for educational leaders, trainers, policy makers, and self-reflective practitioners themselves. First, principals should be understood as capable data analysts, who deserve the investment in more sophisticated interactive tools. To move users from a consumer mindset to that of an empowered and curious seeker of insight, the district could increase investment in advanced analytic tools along with training that includes data literacy preparation and ongoing support. When district leaders work with companies to purchase or design tools, they should place value on greater integration of data sources in order to support cross analysis. In this quest, districts should look not only at tools designed for educators but also those used by the business intelligence industry so that leaders can benefit from the latest developments in other fields. For example, with the collaborative nature of 21st -century jobs, more collaborative visualization tools that are available in the business intelligence sector could

benefit educators by addressing the lack of support and division of labor participants experienced.

Second, seeking a greater balance in data types and tools provided for truly comprehensive data analysis activity as well as avoiding narrowly defining data will continue to be important for school districts. The heavy emphasis on performance data found in this study aligns with previous researchers, who stated that using such data helps to diagnose strengths and weaknesses in student learning but provides few clues on what do about those strengths and weaknesses, leaving educators to rely on professional judgment in deciding what actions to take (Leithwood, 2013). Studies have shown that one of the characteristics of strong districts that are successful at improving the learning of students is the deliberate and consistent use of multiple sources of evidence to inform decisions (Leithwood, 2013). For example, in order to enhance student voice, tools and training that support the collection and analysis of student perceptions are needed on a regular basis. The definition of data informed practice cited earlier (Jimerson, 2016) included the use of evidence that informed strategies to support the academic, social, and emotional needs of students but the majority of data analysis found in this study aligned to academic metrics and not social or emotional needs of students. Greater investment in qualitative data tools is necessary to move away from the accountability culture and emphasis on quantitative assessments. Providing tools that support flexibility and customization will also be important to empower principals to integrate unique metrics that fit their local context while supporting them to create their own visualizations around data they value and want to monitor.

Third, data use in this study varied considerably by individual user; thus, school districts should promote greater awareness of techniques among users along with explicit training to build

consistent practice. An effort should be made to align district support to the characteristics of effective professional development that includes ongoing, job-embedded, differentiated opportunities to learn collaboratively with peer principals (Leithwood, 2013). Principals generally expressed a positive disposition and a willingness to learn that would be conducive to such support. The SLDS standards can be used as a starting point to assess current levels of knowledge, skills, and dispositions related to data use in order to identify areas for new learning. If a varied approach to data analysis were modeled by supervisors, taught explicitly through training, sustained through ongoing learning with peers, and encouraged through a dedicated time structure, then principals would likely find success in making data-informed decisions.

Although numerous tensions and inefficiencies were apparent in the system studied, I am optimistic that districts can overcome these challenges. A more coherent approach to support from the district office could reduce the fragmentation of skill level across schools and bring more equity to leadership practices surrounding data use. The stakeholders and leaders in Hawai‘i are uniquely positioned to utilize the findings from this study to inform future enhancements, but there are also practical implications for any educational leader seeking improvement in this area. For example, any district that hires vendors to design tools can ask their vendors to utilize visual best practices and follow the advice of dashboard design experts (Few, 2014) while iteratively improving tools based on ongoing user feedback.

Future Research

Although this study has provided insight into understanding the principals' experience, a deeper understanding of each theme and relationship is needed. Future research could be conducted in such a way that allows the researcher to ask the principals to reflect on how they

perceive the related components and conceptualize their activity system. Although this research focused on direct relationships between components of the activity systems, further analysis could be conducted to uncover secondary, underlying, or tertiary relationships that may involve more complexity. Further exploration into the division of labor involved in this activity system could also provide additional insight into the experiences of other members within the community involved in supporting data analysis from a perspective other than the principals. Future research on related activity systems could be framed using the third generation of activity theory, which provides a way to explore relationships between interrelated systems in their social and cultural–historical context. For example, additional studies could involve exploration of the related activities of designers, support staff, and teachers as they intersect with the activities of principals. A deeper analysis of these activities over time could foster possibilities to understand the levels of motivated behavior at the activity level, action level, and operation level to determine how unconscious motives impact the conscious choices of users (Kaptelinin & Nardi, 2006).

A better understanding of how specific tool types and various interfaces are used could shed even more light on to how they can be improved. As technology changes and new tools emerge, the everyday use of each product will also change. Future studies could be conducted to evaluate the impact of design improvements on the user experience. Tools such as the Design Version of the Activity Checklist (Kaptelinin & Nardi, 2006) could be useful in future research to increase the alignment between the design and use of tools. If features in the current data platforms are not used by principals, research could be done to determine reasons and potential modifications. If innovation in the business intelligence sector continues to outpace innovation in

educational platforms, a need to discover strategies for closing the gap between the two will remain in place. Perhaps designers could tailor new tools not only for schools but also specifically for principals, and future researchers could explain how insight is impacted by the design elements in the product. Principals may benefit from the opportunity to have a voice in the design and development of such tools. Future studies could be designed to deepen understanding of who is involved in selecting tools at the district level, what criteria are used to guide those decisions, and how those decisions are evaluated on an ongoing basis.

Conclusion and Summary

In the age of information overload, technology has the power to help humans manage large data sets, process complex information, build knowledge from their interpretations, and enhance understanding (Huang et al., 2016). Analytics is the reasoning that occurs in the presence of data; although the term *analytics* is a common in business, it is not used comfortably in education circles (Marker, 2016). With historical underinvestment in tools and training, educators have been unable to benefit from the technology advancements made in the business intelligence sector. This study has provided an overview of the experiences of principals and the challenges they face in using the vast amount of data available to them with the tools available to them. This study has responded to the continued need to understand how principals use data in practice, including both typical activities as well as those resulting from data technology as an intervention (Spillane, 2012).

Researching data use inherently involves the study of human interaction with digital data tools. Instead of looking at just one particular tool, I studied the genre of technology intended to facilitate the analytic processes of principals. Through a two-phased research design

incorporating both an online survey as well as purposefully selected interviews and think-alouds, I was able to describe the types of data and data tools principals used, how they were used, and the impact that use had on their work. I found that principals recognized the underutilization of their data. Using the activity theory framework and UX principles, I was able to identify the ways in which the technology was not as usable as it could be the result of a lack of (a) data visualizations, (b) interactive dashboards, (c) customization, and (d) technological advancements. I then considered the factors in the system as a whole and identified challenges associated with a lack of (a) training, (b) dedicated time, and (c) support in addition to data quality challenges. These challenges were compounded by their situation in the broader educational landscape of shifting policies, accountability, and funding on a national level.

As a result of these findings, I have proposed several recommendations, including the increase of investment in advanced analytic tools along with training for principals. Training should be ongoing, job-embedded, and differentiated in order to be impactful. The district should also seek a greater balance in the variety of data types and tools provided for principals on real-time data dashboards that can support greater situational awareness of a principal's unique role while visually presenting the data in a way that allows for efficient human processing and pattern detection (Marker, 2016). As Big Data analytics enters an era of innovation, competition, and productivity in pursuit of solving the challenges associated with Big Data in the rise of cloud computing (Chen & Zhang, 2014), expanding capabilities will foster limitless possibilities for the application of those tools in education. District leaders are responsible for crafting a clear vision of how they will take advantage of the increasing amount of data in education. With a clear articulation of envisioned practices, identifying tensions and alignments between the envisioned

practice and the reality will be easier. Although gaps still exist between theory and practice, policy and practice, as well as business intelligence technology and educational technology, I have confidence that in the near future, great strides will be made to close those gaps.

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APPENDICES

Appendix A: Permission to Use Figure 3 (Data Use Framework) and Survey Tool (Factors Promoting and Hindering Data-Based Decision-Making in Schools)

From: <k.schildkamp@utwente.nl>
Date: Mon, Nov 20, 2017 at 10:46 PM
Subject: RE: Seeking Permission

Dear Candice,

You can use the image and survey tool, as long as you include our references.

Kind regards,

Kim

Dr. Kim Schildkamp | Associate professor
University of Twente
Faculty of Behavioural, Management & Social Sciences | ELAN
P.O. Box 217 | 7500 AE Enschede
T: +31 53 489 4203 | E: k.schildkamp@utwente.nl
Twitter: https://twitter.com/schildkampkim

Appendix B: Permission to Use Figure 6 (Multiple Measures of Data Image)

From: Victoria L Bernhardt <VBernhardt@csuchico.edu>
Date: Sun, Jan 13, 2019 at 7:07 PM
Subject: Re: Seeking permission for use of image in my dissertation
Cc: Jennifer J Haney <jhaney@csuchico.edu>

Aloha Candice,

Thank you for seeking permission to use the bug's eye!
Please use the attached graphic.

I would love to hear about your research progress.

Thank you,

Victoria L. Bernhardt
Executive Director
Education for the Future
35 Main Street, Suite 204
Chico, CA. 95928-5393
530.898.4482
vbernhardt@csuchico.edu
edforthefuture.com

Appendix C: Permission to Use Figure 7 (Cycle of Visual Analysis)

From: **Kristi Morton** <kmorton@cs.washington.edu>
Date: Tue, Nov 21, 2017 at 8:24 AM
Subject: Re: Seeking Permission

Aloha, Candice!

First, mahalo for your kind words! Please feel free to use the image and citation as you wish.

Your dissertation work is of great interest to me as I am still working on the topic of making it easier for humans to gain insight from data. When your thesis is ready, I would love to read about your findings on the data tools being used by those in the Hawaiian education system.

Best regards,
Kristi

Appendix D: Permission to Use Figure 8 (Example Dashboard)

From: **Keyana Corliss** <kcorliss@tableau.com>
Date: Mon, Nov 27, 2017 at 9:03 AM
Subject: RE: Seeking Permission
CC: Public Relations <pr@tableau.com>

Hi Candice –

You have permission to use this. Please give credit to Tableau and Tableau and Steven Gering, who is quoted in the case study.

Thanks!
Keyana

Appendix E: Permission to Use Figures 10-11 (Activity Theory)

From: Kari Kuutti <kari.kuutti@oulu.fi>
Date: Mon, Nov 20, 2017 at 10:04 PM
Subject: Re: Seeking Permission to Activity Theory Use Images

Hello Candice,
And thanks for your interest. You can by all means have my permission to use the images, but actually the publication rights belong to the publisher, MIT Press. In Europe, however, the common practice is that use of previously published images in a PhD theses without a special permission is OK, as long as the reference to the source is properly mentioned, as you do. Only when you do a commercially available book, tighter rules apply. Please check what is the norm in your institution.

best regards,
and good luck and stamina with your thesis,
—Kari K.

Appendix F: Permission to use Survey Instrument (Teacher Data Use Survey- Admin Version REL 2017-166) and Protocols (Districts' efforts for data use and computer data systems: The role of sensemaking in system use and implementation)

From: Jeff Wayman <jeff@waymandatause.com>
Date: Mon, Nov 27, 2017 at 12:30 PM
Subject: RE: Seeking Permission

Hi Candice,
Thanks for your note. Absolutely, you can have permission to use both the survey and the protocols. The survey is in the public domain and doesn't need permission, but it's nice of you to ask. And I'm happy to send you the protocols. Always happy to support this type of work – especially for a doc student. Feel free to stock up with questions about the TDUS, also – we tried to write that guide so the reader wouldn't need us, but you may have questions anyway.
It might be easier for me to hear more about your work, before sending the protocols, however – I have a bunch of protocols and it's probably worthwhile to narrow it down a bit. So tell me about your work! What's your aim, how big are you going, etc.? And, while you're at it, tell me about your doctoral program! What is your interest, what prof are you working with, etc.?
Thanks – looking forward to hearing about it. Good for you for taking on this study!
Jeff
Jeff Wayman, Ph.D.
Wayman Services, LLC
http://www.waymandatause.com
Twitter: @WaymanDataUse
Facebook: http://www.facebook.com/datause

Appendix G: Phase 1 Survey Instrument

1. How frequently do you use the following forms of data in your role as principal?

Format and scale derived from *Teacher Data Use Survey: Administrator Version* (Wayman et al., 2016). Specific forms of data derived from *A Comparison of Secondary Principals' Use of Data Systems to Increase Student Achievement in Mathematics as Measured by Standardized Assessments* (Williams, 2011).

	Do not use	Less than once a month	Once or twice a month	Weekly or almost weekly	A few times a week
Data about the effectiveness of school programs (e.g., tutoring programs)					
Student language proficiency data					
Feedback data from teachers (e.g., their opinions on how programs designed to enhance student performance are working)					
Teacher observation data					
Report card data					
Standardized test score data					
Benchmark assessment data					
Universal screener data					
Student gender data					
Student socioeconomic data					
Student ethnicity data					
Feedback from students (e.g., opinions on whether a program or class helped them perform better)					
Data about best practices for instruction					
Teacher-generated authentic assessment data					
Data on perceptions of the learning environment (e.g., student, teacher, parent opinion data regarding student preparedness)					
Student attendance data					
Data about curriculum needs					
Student growth data					

Resources management data (budget, etc.)					
School performance data (e.g., Strive HI)					
Other					

2. If you marked Other above, please specify the form of data here:

3. How frequently do you use the following tools in your role as principal?
Format and scale derived from *Teacher Data Use Survey: Administrator Version* (Wayman et al., 2016).

	Do not use	Less than once a month	Once or twice a month	Weekly or almost weekly	A few times a week
Longitudinal data system (lds.k12.hi.us)					
Hawai‘i Statewide Assessment Program Portal (AlohaHSAP.org)					
Infinite Campus (Student Information System)					
SchoolView (http://growthmodel.hawaiipublicschools.org/)					
ARCH Accountability Data Center (https://adc.hidoe.us)					
eCSSS Electronic Comprehensive Student Support Database (https://ecsssonline.k12.hi.us)					
PDE^3 Professional Development Educate, Empower, Excel (https://pde3.k12.hi.us)					
AVA System (Smarter Balanced Interim Assessments)					
Renaissance Learning (https://www.renaissance.com)					
iReady (https://login.i-ready.com)					
Software-Based Student Management System (Jupiter grades)					
Google Suite (Google Forms, Google Classroom, Google Sheets, etc.)					
Excel spreadsheets					
A system devised by your school					
Other					

4. If you marked Other above, please specify the tool here:

5. Computer system characteristics: scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*):

Question derived from *Teacher Data Use Survey: Administrator Version* (Wayman et al., 2016)

I have the proper technology to efficiently examine data.
The computer systems in my district provide me access to lots of data.
The computer systems (for data use) in my district are easy to use.
The computer systems in my district allow me to examine various types of data simultaneously (e.g., attendance, achievement, demographics).
The computer systems in my district generate displays (e.g. reports, graphs, tables) that are useful to me.

Questions 6-9 were adapted from *Factors Affecting Data Use Survey* (Schildkamp et al., 2016) (adaptations shown here but will be corrected in final version)

6. Data characteristics: scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*):
I can find all the data on my students in one system.
I have access to relevant data on my students.
Data on my current students are available at the beginning of each school year (within 3 weeks).
When students start in the middle of the school year, their data becomes quickly available.
The data to which I have access to help me plan my support.
With the data I have on my students, I can determine the growth of my students from year to year.
I have data on the progress of my students.
I have too little data on my students.
The data I have on my students are up to date.
The data I have on my students are accurate.

7. User characteristics: scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*):
I am able to adjust my practice based on data.
I am able to use data to diagnose student learning needs.
I understand the quality criteria and concepts for data use (e.g., correlation, validity, reliability).
I know how to interpret the data and the reports I receive (exam results, student achievement results of previous years).
I am comfortable in interpreting data that are presented in graphs.
It is important to use data in determining individual student needs.
Data are important in changing my practice.
Students benefit when instruction is based on data.

8. School organizational characteristics: scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*):
Our district encourages data use as a tool to support effective teaching.
My supervisor encourages data use as a tool to support effective practice.
My supervisor is a good example of an effective data user.
My supervisor creates many opportunities (e.g. time) for me to use data.

My supervisor discusses the results of their data analyses.
My supervisor discusses data with me.
My school is aware that we need to keep developing the skills of teachers to analyze data.
Teachers in my school share a common understanding about what good teaching is.
Teachers in my school share a common understanding of what student learning is.
Teachers in my school share a common understanding about effective ways to evaluate student learning.
Data use is a priority in my school.
In my school we use a structured method to analyze and interpret data to base actions on.
I am adequately supported in the effective use of data.
There is someone who answers my questions about using data.
There is someone who helps me change my practice based on data.
There is specific time set aside for me to use data.

9. Data use for school development: scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*):
In our school we use external evaluations for our own improvement.
Results of students are used to evaluate teachers.
I show teachers based on data to what extent the school is achieving our goals.
Detailed data analyses are an essential part of improvement processes in my school.
The division of teaching time in my school is based on identified learning needs of students.
In my school we use student results to determine yearly goals for school improvement.
In my school student results lead to decisions with regard to professional development.
Student achievement results are used to identified gaps in our curriculum.
In my school we use data as a tool to determine effective teaching methods.

10. What else would you like to share about data use as a principal?

11. Please indicate the gender you identify with:
    Male
    Female
    Other

12. Please indicate your age range:
    25–39 years
    40–54 years
    55+ years

13. Would you be willing to participate in a follow-up observation and interview session? If so, please include your preferred contact information (i.e. e-mail address or phone number):

_____

Appendix H: Phase 2 Protocol for Think-Aloud and Semistructured Interviews

Overview

Hi my name is Candice Frontiera and I am a student at the University of Hawai‘i. This study is designed to better understand how principals access data, what tools you find helpful, and what it is like using those tools. For the purposes of this conversation, “data” is defined as any information that helps educators do their jobs. Most data will be student data – achievement, demographics, etc. But we’re taking a very broad view of “data” for our conversation.

I want to stress that the goal of the study is not to assess you or your abilities, but rather to understand your experience with specific tools and the information they present to you.

Our time today will be dividing into three segments:

1. Information about the study and informed consent, which will take about 5 minutes
2. A think-aloud and observation, which will take about 30 minutes
3. An interview, which will also take about 30 minutes

Informed Consent and Confidentiality

Your participation is completely voluntary, has no bearing on your job at the DOE, and may be stopped at any time. Let’s review the informed consent document. (Review informed consent document; proceed if consent is obtained).

Your identity is confidential. I will refer to you in the results with a pseudonym and ensure your responses are reported in a way that you cannot be identified or responses traced back to you. I will keep the data on a password protected computer and destroy the files when the study is complete.

Think-Aloud:

During this portion, I ask that you please verbalize your thoughts, actions, or feeling out loud as you demonstrate what you are doing as you are using tools to look at data. Let me give you an example of thinking out loud in a way that describes my actions and feelings:

“When I check my gmail.com, I scan my inbox to see who sent me new messages. I am most likely to click on one that seems urgent and I can tell that by looking at the subject line. I like how the unread messages are in bold so they are easy to see.”

By narrating actions, the thinking behind decisions becomes clearer. As an observer I will be taking notes about your actions but I won’t record any student data if it appears on your screen. The focus of the study is not the data itself but rather your experience using digital tools to access different types of data. The information I gather from you today, combined with other participants, will provide me a better understanding of what is working well and what challenges exists.

In order to be present without trying to write everything down, I would like to ask your permission to record this conversation. The recorder can be turned off anytime you like.

(Turn on recording device if permission is obtained) For the record, do you give your consent for me to record this think-aloud and interview?

1. What are some digital tools (computer systems, websites, software, etc.) you use to interact with data in your job?

2. Would you mind demonstrating on your computer how you use the first digital tool,_____, and talking out loud about what is good about the tool, what is hard about it, how you use it, etc.?
   (Probe for further info, can you tell me more about…)
   Which data do you pay attention to the most?
   What information do you get?
   What do you do next?
   Which features or functions are most helpful to you?
   How typically does this happen?
   How could it be improved?

Repeat #2 above as many times as necessary to demonstrate the tools each principal uses (i.e. second tool, third tool, fourth tool). It is not anticipated that principals would use more than four tools.

3. Are there any data or tools like spreadsheets that you have created on your own? If so can you please demonstrate for me how you use it?
   (Probe for further info, how often, what they like and dislike)
   Which data do you pay attention to the most?
   What information do you get?
   What do you do next?
   Which features or functions are most helpful to you?
   How typically does this happen?

4. In reviewing your school's Academic Plan, I noticed _____indicator of progress was mentioned. How do you access and analyze data for that indicator of progress?
   Listen for school-specific measures
   Listen for what they really like to use and what's useful to them.
   Listen for how they access – computer? Paper reports?
   Listen for any reports they may create on their own

5. Is there anything else you would like to share?

Semistructured Interview
Questions adapted from Wayman and Cho (2014) and Marker (2016)
We are now going to transition in the interview portion; you will no longer need your computer to demonstrate the tools.

1. How would you describe the impact of data use on your work? (Cho & Wayman, 2014)

2. Can you give me an example of a planning decision you made recently which was prompted by information you gained from (this tool)? This is a key question; probes or follow-ups will be essential here. (Marker, 2016)
   Which specific data were most important? (Cho & Wayman, 2014)

3. Walk me through the process that enabled (your school) to use the (name of data tool) to implement (the specific changes) you have made. *(Marker, 2016)*

4. How would you complete the following sentence? "Using digital data tools is like using _____ because _____." *(Marker, 2016)*

5. Do the digital tools you use to access data do what you want them to?
   What do you do when you need help? (Cho & Wayman, 2014)

6. How do these data systems affect your job? Your typical day? (Cho & Wayman, 2014)

7. How do other staff factor into these activities? (Cho & Wayman, 2014)

8. Are you well-positioned to make effective use of data? (Cho & Wayman, 2014)
   Probe the following as needed…
   Do you have the right preparation/background to effectively use data?

   Training in their degrees, workshops, whatever

   Help the district has given them

   Where they're getting their knowledge.

   What they think they might need.

9. Have you had any professional development you see as invaluable for this work? *(Marker, 2016)*

10. Why might some principals be unable or unwilling to make successful use of (this tool)? *(Marker, 2016)*

11. Imagine that you woke up tomorrow and your challenges around data use had been solved. What would have happened? (Cho & Wayman, 2014)

12. How much emphasis does your district place on using data systems? How is that emphasis shared with you? (Cho & Wayman, 2014)

13. What has the district been doing this year to improve data use? (Cho & Wayman, 2014)
    How have these efforts involved computer data systems?
    How are these efforts working out?

14. Is there anything else you'd like to add?

I'd like to thank you for your participation in this research study.

Appendix I: Phase 2 Field Notes Template

Date:_____Time:_____
Location:_____

Sketch of room and equipment:

Observations	Researcher's Thoughts/Irregularities

Appendix J: Institutional Review Board Approval

UNIVERSITY of HAWAI'I® SYSTEM

Office of Research Compliance
Human Studies Program

TO:	Irvine, Christine, PhD, University of Hawaii at Manoa, Department of Learning Design and Technology Ho, Curtis, University of Hawaii at Manoa, Department of Learning Design and Technology, Frontiera, Candice, College of Education, University of Hawaii at Manoa
FROM:	Rivera, Victoria, Interim Dir, Ofc of Rsch Compliance, Social & Behavioral
PROTOCOL TITLE:	A Mixed Methods Study of Principals# Experience Using Data Analytic Tools in Hawaii
FUNDING SOURCE:	
PROTOCOL NUMBER:	2017-00948
APPROVAL PERIOD:	Approval Date: January 12, 2018 Expiration Date: December 31, 2018

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Under an expedited review procedure, the research project identified above was approved for one year on January 12, 2018 by the University of Hawaii Institutional Review Board (UH IRB). The application qualified for expedited review under CFR 46.110 and 21 CFR 56.110, Category 6, 7a, 7b.

This memorandum is your record of the IRB approval of this study. Please maintain it with your study records.

The UH IRB approval for this project will expire on December 31, 2018. If you expect your project to continue beyond this date, you must submit an application for renewal of this Human Studies Program approval. The Human Studies Program approval must be maintained for the entire term of your project.

If, during the course of your project, you intend to make changes to this study, you must obtain approval from the Human Studies Program prior to implementing any changes. If an Unanticipated Problem occurs during the course of the study, you must notify the Human Studies Program within 24 hours of knowledge of the problem. A formal report must be submitted to the Human Studies Program within 10 days.The definition of "Unanticipated Problem" may be found at the HSP Policies & Guidance website, www.hawaii.edu/researchcompliance/policies-guidance, and the report form may be downloaded from the website www.hawaii.edu/researchcompliance/report-protocol-violation-or-unanticipated-problem.

You are required to maintain complete records pertaining to the use of humans as participants in your research. This includes all information or materials conveyed to and received from participants as well as signed consent forms, data, analyses, and results. These records must be maintained for at least three years following project completion or termination, and they are subject to inspection and review by the Human Studies Program and other authorized agencies.

Please notify this office when your project is complete. Upon notification, we will close our files pertaining to your project. Reactivation of the Human Studies Program approval will require a new Human Studies Program application.

Please contact this office if you have any questions or require assistance. We appreciate your cooperation, and wish you success with your research.

1960 East-West Road
Biomedical Sciences Building B104
Honolulu, Hawai'I 96822
Telephone: (808) 956-5007
Fax: (808) 956-8683
An Equal Opportunity/Affirmative Action Institution

Appendix K: District Approval to Conduct Research

STATE OF HAWAIʻI
DEPARTMENT OF **EDUCATION**
P.0 . BOX 2360 HONOLULU, HAWAIʻI 96804

March 9, 2018
Re: Research Application Decision

Dear Ms. Frontiera:

I am pleased to approve your Hawaii State Department of Education (HIDOE) research application for the study "A Mixed Methods Study of Principals' Experience Using Data Analytic Tools in Hawai'i" (Application RES201800 I).

This approval will expire October 31, 2018. If you require additional time to complete your study, you must submit a request for an extension or another application before this approval expires. If you intend to make changes to your project you must submit the change request to the Data Governance and Analysis Branch prior to implementing the change. These changes include but are not limited to (I) any changes that require approval from your Institutional Review Board and (2) any changes that are in conflict with or not included in this approval letter. Significant changes may need to be reviewed by the Research Review Committee at their next scheduled meeting. If changes are approved, a modified approval letter will issued to the researcher, the targeted schools, and affiliated state/district office staff.

As described in your application, the objective of your study is:

- To understand the experiences of principals using digital data analytic tools in a K-12 setting.

You have indicated that you will be inviting all HIDOE schools to participate in your study (see Attachment 1).
You must present this letter to the appropriate HIDOE administrator(s) upon invitation to participate in your research.

You have also indicated that you will be inviting the following individuals at these targeted schools to participate in your study:

- Principals

The number of participants is contingent upon how many schools agree to participate in your project.

Principals who participate in your study will be involved in the following activities:

1. Online surveys
2. Document analysis (for principals who volunteer to participate in Phase 2)
3. Observations (for principals who volunteer to participate in Phase 2)
4. Semi-structured interviews (for principals who volunteer to participate in Phase 2)
5. Member checks to verify data collection is accurate (for principals who volunteer to participate in Phase 2)

As you proceed with your study, please be aware of the following:

- The participation of HIDOE schools, offices, students, and personnel in your study is strictly voluntary.
- All study activities must take place at dates, times, and locations agreed upon by the administrators of the participating HIDOE schools and offices.
- Any compensation provided to HIDOE personnel for participation in your study must be for activities completed outside of instructional and work hours and must be in compliance with the Hawaii State Ethics Code. Any questions about this topic should be referred to the Data Governance and Analysis Branch.
- You are required to conduct your study in accordance with both the conditions of approval described in this letter and the document "Affirmation and Acknowledgement of the Processes, Procedures, and Conditions for Conducting Research in the Hawaii State Department of Education" (the "Affirmation Form for Researchers")
- You are responsible for ensuring that all individuals involved in this study- both those affiliated with your organization and those contracted by your organization and affiliated with external entities or vendors - adhere to all of the conditions of my approval, including those detailed in this letter and those stipulated by the Affirmation Form for Researchers.

Should you have any questions about the above, please contact Ke'ala Fukuda, HIDOE Data Governance and Analysis Branch, at DOEresearch@notes.k12.hi.us or (808) 784-6061.

Best wishes for a successful study. We look forward to receiving your findings and recommendations. Sincerely,

Rodney Luke
Interim Assistant Superintendent

RL:kf
Attachment: School List

c: Data Governance and Analysis Branch

Target HIDOE Schools and Offices for HIDOE Research Application

Please indicate the target HIDOE schools and offices for your application by placing an "x" to the left of the appropriate school categories or individual schools/offices.

Application # (assigned by HIDOE):

x	**All Schools** (all 255 non-charter schools)
	All Elementary schools (all 179 non-charter schools)
	All Middle Schools (all 55 non-charter schools)
	All High Schools (all 46 non-charter schools)

IMPORTANT: If applicable, please use the blue grouping options FIRST. Otherwise, editing the cells next to individual school names will break the formulas used to autofill. Please note that the blue categories are additive (e.g., if you select both "All Elementary Schools" and "Central District," the form will select all elementary schools across the state, including those in Central District, plus all other schools in Central District)

	Central District Schools (all 42 schools)
	Aiea-Moanalua-Radford Complex Area (all 22 schools)
	Aiea Complex (all 7 schools)
x	Aiea Elementary
x	Aiea High
x	Aiea Intermediate
x	Alvah A. Scott Elementary
x	Gustav H. Webling Elementary
x	Pearl Ridge Elementary
x	Waimalu Elementary
	Moanalua Complex (all 6 schools)
x	Major General William R. Shafter Elementary
x	Moanalua Elementary
x	Moanalua High
x	Moanalua Middle
x	Red Hill Elementary
x	Salt Lake Elementary
	Radford Complex (all 9 schools)
x	Admiral Arthur W. Radford High
x	Admiral Chester W. Nimitz Elementary
x	Aliamanu Elementary
x	Aliamanu Middle
x	Lt. Col. Horace Meek Hickam Elementary
x	Makalapa Elementary
x	Mokulele Elementary
x	Pearl Harbor Elementary
x	Pearl Harbor Kai Elementary
	Leilehua-Mililani-Waialua Complex Area (all 20 schools)
	Leilehua Complex (all 10 schools)
x	Hale Kula Elementary
x	Helemano Elementary
x	Iliahi Elementary
x	Ka'ala Elementary
x	Leilehua High
x	Major Sheldon Wheeler Elementary
x	Major Sheldon Wheeler Middle
x	Sergeant Samuel K. Solomon Elementary
x	Wahiawa Elementary
x	Wahiawa Middle
	Mililani Complex (all 7 schools)
x	Kipapa Elementary
x	Mililani High
x	Mililani 'Ike Elementary
x	Mililani Mauka Elementary
x	Mililani Middle
x	Mililani Uka Elementary
x	Mililani Waena Elementary
	Waialua Complex (all 3 schools)
x	Hale'iwa Elementary
x	Waialua Elementary
x	Waialua High & Intermediate
	Hawaii District Schools (all 41 schools)
	Hilo-Waiakea Complex Area (all 13 schools)
	Hilo Complex (all 9 schools)
x	Chiefess Kapi'olani Elementary
x	Ernest Bowen de Silva Elementary
x	Ha'aheo Elementary
x	Hilo High
x	Hilo Intermediate
x	Hilo Union Elementary
x	Ka'umana Elementary
x	Keaukaha Elementary
x	Prince Jonah Kuhio Kalaniana'ole Elem & Inter
	Waiakea Complex (all 4 schools)
x	Waiakea Elementary
x	Waiakea High
x	Waiakea Intermediate
x	Waiakeawaena Elementary
	Honokaa-Kealakehe-Kohala-Konawaena Complex Area (all 19 schools)
	Honokaa Complex (all 4 schools)
x	Honoka'a Elementary
x	Honoka'a High & Intermediate
x	Pa'auilo Elementary & Intermediate
x	Waimea Elementary
	Kealakehe Complex (all 6 schools)
x	Hollualoa Elementary
x	Kahakai Elementary
x	Kealakehe Elementary
x	Kealakehe High
x	Kealakehe Intermediate
x	Waikoloa Elementary & Middle
	Kohala Complex (all 3 schools)
x	Kohala Elementary
x	Kohala High
x	Kohala Middle
	Konawaena Complex (all 6 schools)
x	Honaunau Elementary
x	Ho'okena Elementary
x	Ke Kula 'o 'Ehunuikaimalino
x	Konawaena Elementary
x	Konawaena High
x	Konawaena Middle
	Kau-Keaau-Pahoa (all 9 schools)
	Kau Complex (all 2 schools)
x	Ka'u High & Pahala Elementary
x	Na'alehu Elementary
	Keaau Complex (all 4 schools)
x	Kea'au Elementary
x	Kea'au High
x	Kea'au Middle
x	Mountain View Elementary
	Pahoa Complex (all 3 schools)
x	Keonepoko Elementary
x	Pahoa Elementary
x	Pahoa High & Intermediate
	Honolulu District Schools (all 53 schools)
	Farrington-Kaiser-Kalani (all 25 schools)
	Farrington Complex (all 12 schools)
	Kauai District Schools (all 17 schools)
	Kapaa-Kauai-Waimea Complex Area (all 16 schools)
	Kapaa Complex (all 5 schools)
x	Kapa'a Middle
x	Hanalei Elementary
x	Kapa'a Elementary
x	Kapa'a High
x	Kilauea Elementary
	Kauai Complex (all 5 schools)
x	Chiefess Kamakahelei Middle
x	Elsie H. Wilcox Elementary
x	Kaua'i High
x	King Kaumuali'i Elementary
x	Koloa Elementary
	Waimea Complex (all 7 schools)
x	Ele'ele Elementary
x	Kalaheo Elementary
x	Kekaha Elementary
x	Ni'ihau High & Elementary
x	Waimea Canyon Middle
x	Waimea High
	Leeward District Schools (all 42 schools)
	Campbell-Kapolei Complex Area (all 16 schools)
	Campbell Complex (all 10 schools)
x	Ewa Beach Elementary
x	Ewa Elementary
x	Ewa Makai Middle
x	Holomua Elementary
x	Ilima Intermediate
x	Iroquois Point Elementary
x	James Campbell High
x	Kaimiloa Elementary
x	Keone'ula Elementary
x	Pohakea Elementary
	Kapolei Complex (all 6 schools)
x	Barbers Point Elementary
x	Kapolei Elementary
x	Kapolei High
x	Kapolei Middle
x	Makakilo Elementary
x	Mauka Lani Elementary
	Nanakuli-Waianae Complex Area (all 9 schools)
	Nanakuli Complex (all 3 schools)
x	Nanaikapono Elementary
x	Nanakuli Elementary
x	Nanakuli High & Intermediate
	Waianae Complex (all 6 schools)
x	Leihoku Elementary
x	Ma'ili Elementary
x	Makaha Elementary
x	Wai'anae Elementary
x	Wai'anae High
x	Wai'anae Intermediate
	Pearl City - Waipahu Complex Area (all 17 schools)
	Pearl City Complex (all 10 schools)
x	Highlands Intermediate
x	Kanoelani Elementary
x	Lehua Elementary
x	Manana Elementary
x	Momilani Elementary
x	Palisades Elementary
x	Pearl City Elementary
x	Pearl City High
x	Pearl City Highlands Elementary
x	Waiau Elementary
	Waipahu Complex (all 7 schools)
x	August Ahrens Elementary
x	Honowai Elementary
x	Kalei'opu'u Elementary
x	Waikele Elementary
x	Waipahu Elementary
x	Waipahu High
x	Waipahu Intermediate
	Maui District Schools (all 31 schools)
	Baldwin-Kekaulike-Maui Complex Area (all 31 schools)
	Baldwin Complex (all 5 schools)
x	Henry Perrine Baldwin High
x	Iao Intermediate
x	Pu'u Kukui Elementary
x	Waihe'e Elementary
x	Wailuku Elementary
	Kekaulike Complex (all 7 schools)
x	Ha'iku Elementary
x	King Kekaulike High
x	Kula Elementary
x	Makawao Elementary
x	Pa'ia Elementary
x	Pukalani Elementary
x	Samuel Enoka Kalama Intermediate
	Maui Complex (all 8 schools)
x	Kahului Elementary
x	Kamali'i Elementary
x	Kihei Elementary
x	Lihikai Elementary
x	Lokelani Intermediate
x	Maui High
x	Maui Waena Intermediate
x	Pomaika'i Elementary
	Hana-Lahainaluna-Lanai-Molokai (all 11 schools)
	Hana Complex (1 school)
x	Hana High & Elementary
	Lahainaluna Complex (all 4 schools)
x	King Kamehameha III Elementary
x	Lahaina Intermediate
x	Lahainaluna High
x	Princess Nahi'ena'ena Elementary
	Lanai Complex (1 school)
x	Lanai High & Elementary

x	Governor Sanford B. Dole Middle
x	Governor Wallace Rider Farrington High
x	Ka'ewai Elementary
x	Kalihi Elementary
x	Kalihi Waena Elementary
x	Kalihi-kai Elementary
x	Kalihi-uka Elementary
x	Kapalama Elementary
x	King David Kalakaua Middle
x	Linapuni Elementary
x	Mayor Joseph J. Fern Elementary
x	Pu'uhale Elementary
	Kaiser Complex (all 6 schools)
x	Aina Haina Elementary
x	Haha'ione Elementary
x	Henry J. Kaiser High
x	Kamiloiki Elementary
x	Koko Head Elementary
x	Niu Valley Middle
	Kalani Complex (all 7 schools)
x	Hawaii School for the Deaf and Blind
x	Kahala Elementary
x	Kaimuki Middle
x	Kalani High
x	King Lihoiliho Elementary
x	Mayor John H. Wilson Elementary
x	Waikiki Elementary
	Kaimuki-McKinley-Roosevel (all 28 schools)
	Kaimuki Complex (all 10 schools)
x	Ala Wai Elementary
x	Ali'iolani Elementary
x	Hokulani Elementary
x	Kaimuki High
x	King William Lunalilo Elementary
x	Palolo Elementary
x	President George Washington Middle
x	President Thomas Jefferson Elementary
x	Prince Jonah Kuhio Elementary
x	William P. Jarrett Middle
	McKinley Complex (all 8 schools)
x	Central Middle
x	Kauluwela Elementary
x	Lanakila Elementary
x	President William McKinley High
x	Princess Miriam K. Likelike Elementary
x	Princess Victoria Ka'iulani Elementary
x	Queen Ka'ahumanu Elementary
x	Royal Elementary School
	Roosevelt Complex (all 10 schools)
x	Kula Kaiapuni 'O Anuenue
x	Ma'ema'e Elementary
x	Manoa Elementary
x	Noelani Elementary
x	Niu'uanu Elementary
x	Pauoa Elementary
x	President Abraham Lincoln Elementary
x	President Theodore Roosevelt High
x	Prince David Kawananakoa Middle
x	Robert Louis Stevenson Middle
State Offices	
	Office of the Superintendent
	Office of the Deputy Superintendent
	Office of Curriculum, Instruction and Student Support
	Office of Fiscal Services
	Office of Human Resources
	Office of Information Technology Services
	Office of Strategy, Innovation and Performance
	Office of School Facilities and Support Services
District Offices	
	Honolulu District Office
	Central District Office
	Leeward District Office
	Windward District Office
	Hawaii District Office
	Maui District Office
	Kauai District Office

	Molokai Complex (all 5 schools)
x	Kaunakakai Elementary
x	Kilohana Elementary
x	Maunaloa Elementary
x	Moloka'i High
x	Moloka'i Middle
	Windward District Schools (all 30 schools)
	Castle-Kahuku Complex Area (all 16 schools)
	Castle Complex (all 10 schools)
x	Ahuimanu Elementary
x	Governor Samuel Wilder King Intermediate
x	He'eia Elementary
x	James B. Castle High
x	Kahalu'u Elementary
x	Kane'ohe Elementary
x	Kapunahala Elementary
x	Pu'ohala Elementary
x	Reverend Benjamin Parker Elementary
x	Waiahole Elementary
	Kahuku Complex (all 6 schools)
x	Hau'ula Elementary
x	Ka'a'awa Elementary
x	Kahuku Elementary
x	Kahuku High & Intermediate
x	La'ie Elementary
x	Sunset Beach Elementary
	Kailua-Kalaheo Complex Area (all 14 schools)
	Kailua Complex (all 8 schools)
x	Blanche Pope Elementary
x	Enchanted Lake Elementary
x	Ka'elepulu Elementary
x	Kailua High
x	Keolu Elementary
x	Maunawili Elementary
x	Olomana
x	Waimanalo Elementary & Intermediate
	Kalaheo Complex (all 6 schools)
x	Aikahi Elementary
x	Kailua Elementary
x	Kailua Intermediate
x	Kainalu Elementary
x	Kalaheo High
x	Mokapu Elementary
	All Charter Schools (all 35 schools)
	Connections New Century Public Charter School
	Hakipu'u Learning Center New Century Public Charter School
	Halau Ku Mana New Century Public Charter School
	Halau Lokahi New Century Public Charter School
	Hawai'i Academy of Arts & Science Public Charter School
	Hawai'i Technology Academy Public Charter School
	Innovations Public Charter School
	Ka 'Umeke Ka'eo Public Charter School
	Ka Waihona o ka Na'auao: New Century Public Charter School
	Kamaile Academy Public Charter School
	Kanuikapono Learning Center Public Charter School
	Kawaikini New Century Public Charter School
	Ke Ana La'ahana Public Charter School
	Ke Kula Ni'ihau O Kekaha Learning Center Public Charter School
	Ke Kula 'o Nawahiokalani'opu'u Iki Laboratory Public Charter School
	Kona Pacific Public Charter School
	Kua 'O Ka La Public Charter School
	Kualapu'u Elementary New Century Public Conversion Charter School
	Kula Aupuni Niihau A Kahelelani Aloha (KANAKA), A New Century Public Charter School (PCS)
	Kula Aupuni Niihau A Kahelelani Aloha New Century Public Charter School
	Lanikai Elementary Public Charter School
	Laupahoehoe Community PCS
	Malama Honua Learning Center
	Na Wai Ola New Century Public Charter School
	School for Examining Essential Questions of Sustainability Public Chater School
	Volcano School of Arts & Sciences Community Public Charter School
	Voyager Public Charter School
	Wai'alae Elementary Public Charter School
	Waimea Middle Public Conversion Charter School
	West Hawai'i Explorations Academy Public Charter School
	Kanu 'o ka 'Aina New Century Public Charter School
	Ke Kula 'O Samuel M. Kamakau Laboratory Public Charter School
	Kihei Public Charter High School
	Myron B. Thompson Academy New Century Public Charter School
	University Laboratory School

Appendix L: Initial Email Invitation to Participate in Phase 1 Survey

Aloha,

My name is Candice Frontiera and I am a graduate student at the University of Hawai‘i at Mānoa in the Department of Learning Design and Technology. I have been an educator in the Hawai‘i Department of Education for over 10 years. As part of the requirements for earning my graduate degree, I am conducting research to better understand the experience of school principals using digital tools for data analysis. I am inviting you to participate because you are a public school principal in Hawai‘i.

The purpose of this study is to better understand how principals access data, what tools you find helpful, and what it is like using those tools. Your perspective is important. I want to stress that your responses will be kept completely confidential and will only be reported in aggregate trends, not individually. The first phase of my research is an online survey that will provide a picture of how principals use data. Participation is completely voluntary. The survey will be open from March 20-April 20, 2018**.** Attached is a copy of the DOE approval letter. The survey will take about 10-15 minutes to complete. Please click the link below for the survey and consent form:

http://www.surveyshare.com/t/Principals-Data-Use

Thank you for your consideration,

Candice Frontiera

Appendix M: Consent Form to Participate in Survey

University of Hawai‘i
Consent to Participate in a Research Project
Candice Frontiera, Principal Investigator
A Mixed Methods Study of Principals' Experience Using Data Analytic Tools in Hawai‘i

Aloha,

My name is Candice Frontiera and I am a graduate student at the University of Hawai‘i at Mānoa in the Department of Learning Design and Technology. I have also been an educator in the Hawai‘i Department of Education for over 10 years. As part of the requirements for earning my graduate degree, I am conducting research to better understand the experience of school principals using digital tools for data analysis. I am inviting you to participate because you are a school principal in the Hawai‘i Department of Education.

Project Description – Activities and Time Commitment: If you decide to take part in this voluntary project, you will be asked to fill out an online survey. The survey questions are mainly multiple choice. However, there are a few questions where you may add an open-ended response. Completing the survey will take approximately 15 minutes.

Benefits and Risks: There is no direct benefit to you for taking part in this project. The aggregate findings will be shared with the Hawai‘i Department of Education and made available to the participants when the study is complete. No individuals will be identified. The findings have the potential to inform improvements in the data analytic tools provided, training and support, as well as opportunities for principals to learn best practices from each other. There is little risk to you for participating in this project.

Confidentiality and Privacy: You are not required to provide any personal information. Data will be secured to protect privacy. The surveys are anonymous however, you will have the opportunity to voluntarily provide contact information if you wish to participate in the second phase of this research which involves an interview and a think-aloud session where the researcher will ask you to describe your use of the tools while using them. If you provide your contact information it will be kept confidential and only seen by the researcher.

Voluntary Participation: You can freely choose to take part or to not in this survey. There will be no penalty or loss of benefits for either decision. If you agree to participate, you can stop at any time. Survey participation does not commit you to participating in phase 2 of the study.

Questions: If you have any questions or concerns, please contact me at [number redacted] or blohm@hawaii.edu. You may also contact my advisor, Dr. Christine Sorensen Irvine, at sorens@hawaii.edu or the UH Human Studies Program at [number redacted] or uhirb@hawaii.edu. Please visit https://www.hawaii.edu/researchcompliance/information-research-participants for more information on your rights as a research participant.

To Access the Survey: Please go to the following web page: (_____). You should find a link and instructions for completing the survey. Going to the first page of the survey will be considered as your consent to participate in this study.

Please print a copy of this page for your reference. Mahalo!

Click here to begin the survey

Appendix N: Email Reminder to Participate in Phase 1 Survey

Aloha,

My name is Candice Frontiera and I am a student at the University of Hawai‘i and a fellow employee at the Hawai‘i Department of Education. I recently sent an email inviting you to participate in a survey about how principals use data in their schools. If you have not completed the survey, please take 15 minutes to do so.

The purpose of this study is to better understand how principals access data, what tools you find helpful, and what it is like using those tools. Your perspective is important. I want to stress that your responses will be kept completely confidential and will only be reported in aggregate, not individually. This survey will provide a picture of how principals use data and will be hopefully be useful in improving the tools and support. All principals in the Hawai‘i Department of Education are being asked to complete this survey. The survey will be open until (provide closing date).

Please click the link below to go to the consent form and survey. Thank you for your time and participation,

Candice Frontiera

Appendix O: Email Invitation to Participate in Phase 2

Dear Principal_____,

My name is Candice Frontiera, I am a student at the University of Hawai‘i and a fellow educational officer in the Hawai‘i Department of Education. Thank you for participating in my recent survey about digital tools used for data analysis. On that survey you indicated potential willingness to participate in the second phase of my study. Participation will consist of a think-aloud observation (30-45 minutes) and an interview session (30-45 minutes) with the goal of understanding how you access data, what tools you find helpful, and what it is like using digital data tools.

If you are willing to spend 1-1.5 hours meeting with me, please respond to this email and I will follow up to find a date, time, and location convenient for you and provide a consent form for your review. That consent will be signed at the time that we meet.

I would be happy to share more information about my research and share the results when I finish. I am hoping the results of this study will be useful in improving the tools and support principals receive for data use. Please don’t hesitate to ask any questions you might have through email or phone.

Thank you for your consideration,

Candice Frontiera

Appendix P: Confirmation Email to Participate in Phase 2

Dear Principal _____,

Thank you for agreeing to participate in the second phase of my research study. The data collection will consist of a think-aloud session where you describe for me what you are doing with the tools while you are using them (30-45 minutes) and an interview afterward (30-45 minutes) to help me better understand your use of these tools. I am appreciative of your willingness to participate and would like to honor your preferences while coordinating a few logistics:

1. Please indicate at least three dates and times that would work for you.
2. Do you have a preferred location that would be convenient for you where distractions and background noise can be minimized (i.e. an office or a conference room)?
3. Do you have a computer you feel comfortable using during the think-aloud or would you prefer that I supply a laptop?

Attached you will see the interview questions I plan to ask and the informed consent form I will be asking you to sign. Please don't hesitate to reach out to me with any questions you may have. I look forward to hearing from you.

Thank you so much,
Candice Frontiera

Appendix Q: Consent Form to Participate in Phase 2

University of Hawai‘i
Consent to Participate in a Research Project
Candice Frontiera, Principal Investigator
A Mixed Methods Study of Principals' Experience Using Data Analytic Tools in Hawai‘i

Aloha,

My name is Candice Frontiera and I am a graduate student at the University of Hawai‘i at Mānoa in the Department of Learning Design and Technology. I have also been an educator in the Hawai‘i Department of Education (DOE) for over 10 years. As part of the requirements for earning my graduate degree, I am conducting research to better understand the experience of school principals using digital tools for data analysis. I am inviting you to participate because you are a school principal in the Hawai‘i DOE.

Activities and Time Commitment: If you participate in this project, I will meet with you for a 30-45 minute think-aloud observation session followed by a 30-45 minute interview at a location and time convenient for you. Interview questions will include questions like, "Which computer data systems are most helpful to you? " "How would you describe the impact of data use on your work?" Only you and I will be present during the think-aloud observation and interview. With your permission, I will audio-record the think-aloud and interview so that I can later transcribe and analyze the responses. You will be one of about six people I will interview for this study.

Benefits and Risks: There will be no direct benefit to you for taking part in this project other than the opportunity to think more deeply about your data use practices as a principal. The aggregate findings will be shared with the Hawai‘i Department of Education and made available to the participants when the study is complete. The findings from this study may be used to improve the digital tools provided for principals, the training and support provided, as well as the provide opportunities for principals to learn from each other. I believe there is little risk to you for participating in this research project. If you become stressed or uncomfortable during the interview or observation, you can skip questions or take a break. You can also stop the interview or withdraw from the project.

Privacy and Confidentiality: Participation in the study is voluntary. I will keep all data secure on a password-protected computer. Only my University of Hawai‘i advisor and I will have access to the information. The University of Hawai‘i Human Studies Program has the right to review research records for this study. After I transcribe the interview and observation data, I will erase the audio-recordings. When I report the results of my research project, I will not use your name or any other identifying information. I will use pseudonyms (fake names) and report my findings in a way that protects your privacy and confidentiality to the extent allowed by law. As a fellow employee at the Hawai‘i Department of Education I understand the confidential nature of student data and want you to know that if any student data appears on your computer screen as you demonstrate the tools I will not be recording it. Please know that student data is not the focus of this study. The focus of this study is on the experience of principals using digital tools to analyze a variety of data for school improvement.

Voluntary Participation: Your participation in this project is completely voluntary. You may stop participating at any time. If you stop being in the study, there will be no penalty or loss to you. Your choice to participate or not participate will not affect your job as a principal.

Compensation:
You will receive a box of macadamia nuts for your time and effort in participating in this research project.

Questions: If you have any questions or concerns about this study, please contact me at 808-542-4578 or Candice_Frontiera@notes.k12.hi.us. You may also contact my advisor, Dr. Christine Sorensen Irvine, at sorens@hawaii.edu or the UH Human Studies Program at 808.956.5007 or uhirb@hawaii.edu. For more information on your rights as a research participant, visit https://www.hawaii.edu/researchcompliance/information-research-participants.

Please print a copy of this page for your reference.

Signature(s) for Consent (to be completed at the time of the observation/interview):

I agree to participate in the research project entitled, *A Mixed Methods Study of Principals' Experience Using Data Analytic Tools in Hawai'i* and understand that participation includes an observation session and interview.

Please initial next to either "Yes" or "No" to indicate your consent to being audio-recorded.
_____ Yes _____ No

Name of Participant (Print): _____

Participant's Signature: _____

Date: _____

Signature of the Person Obtaining Consent: _____

Mahalo!