Blended Learning and Data Use in Three Technology-Infused Charter Schools

A Report to the Bill and Melinda Gates Foundation

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Executive Summary

This report provides a description of a study conducted by WestEd on behalf of the Bill and Melinda Gates Foundation to examine how the affordances of the technologies in the blended learning environments of three charter schools impacted teaching and learning activities. A particular focus of the work was to examine whether the blended learning environments provided enhanced access to and more diverse data sources for teachers and students from which to make educational decisions.

The research was conducted in three small charter schools in Arizona, serving populations of challenged middle and high school students. The schools were infused with technologies that support in-person and distant educational experiences, using a hybrid model. Teachers and administrators were well trained in the use of the technologies and how they could be used to enhance instructional and administrative decision making. The school administrators provided for ongoing professional development, technical assistance, and other learning opportunities to assist the teachers to effectively integrate the technologies into the teaching and learning process. Findings from the research are consistent with results from related studies on blended learning and recommendations for the effective use of data.

The school administrators provided strong leadership and a clear vision for the use of the technologies and data to enhance teaching and learning. They provided the needed resources to make possible the effective use of both the technologies and data in the form of ongoing professional learning opportunities. They created and enculturated the use of technology and data through data teams, data coaches, and dedicated planning time. They involved not only the teachers but also the students as active participants in the teaching and learning process. Technologies were used to enhance the process both within the school buildings and virtually. Students had ready access to a diversity of technological solutions at school and outside of school. The blended learning environments provided for any time, any where access to educational activities for the students. This was an essential component given the many challenges faced by the students. Students could access instructional and assessment materials via mobile devices at their convenience. The hybrid model was not reliant on in-person attendance in class, although it was strongly recommended. The environments allowed for customization to personalized learning goals and needs with flexible pathways to learning for each student.

The research used a purposive sample of three schools, leaving open the question of whether the findings can generalize to other similar charter schools as well as to more traditional schools. Not all schools are steeped in technology. Not all schools have strong leadership with targeted visions on how technology and data can be used to meet the needs of all students. Not all schools can provide the kinds of resources to build and sustain the human capacity of the educational staff to use the technologies and data.

Yet even with these resources, the schools faced challenges. Despite the plethora of technological solutions, the data from them were siloed, meaning that there was little interoperability and connectedness. There was no single data repository. The lack of interoperability created problems in terms of ease of access and the linking of diverse sources of data. Bandwidth was an issue. The heavy reliance on connectivity within the school buildings meant that there must be substantial bandwidth to accommodate all the technologies. Connectivity beyond the schools also was an issue. Most, if not all students, had mobile devices of their own. However, they might not have data plans, creating the need to find WiFi enabled sites from which to do their work virtually. This was not always the case. Not all students had WiFi at their home situations.

In terms of the teachers, the blended learning process provided both opportunities and challenges. Teachers had access to a multitude of resources. Teachers needed to be creative and thoughtful about how they used the resources. There was a continuous learning process for them as well as their students. For some, it took them out of their comfort zone by changing the structure of the traditional classroom. Students were more engaged and active. Students were also engaged any time and any where, which meant that teachers were sometimes working 24/7 and certainly beyond the confines of the school. The labor intensiveness of the teaching and learning process can take its toll on the staff, through turnover and mobility.

There is no doubt that education, whether in traditional or blended environments, is a challenging enterprise. That said, the affordances of the technologies in the three schools in this project provided opportunities in the teaching and learning process that most likely would have not been possible if they were in more traditional settings. The teachers were able to address the needs of particular students through various media and diverse learning experiences. The ability to move the educational process beyond the school walls seemingly was an essential component. The ability to engage the students by providing flexible and customizable learning activities also was a key component. The technologies made possible such personalization. Other characteristics of these schools are, however, generalizable to traditional environments – strong leadership, an explicit vision for the use of technology and data, the engagement of students in the teaching and learning process, the enculturation of data use through data teams and data coaches, and the provision of professional learning opportunities. The three schools were fortunate to have these important components, yet there are other challenges to overcome. Education is difficult and complex at best. The blended learning process helped the teachers in these schools better meet the needs of their students. That is progress.

Introduction[1]

The purpose of this paper is to explore how the affordances of blended learning environments provide data for educational decision making to administrators, teachers, and students that might not be otherwise available. Because blended learning environments have significant technology infusion, those applications are likely to yield a plethora of data that can assist educators to inform their practice in formats and real-time feedback loops not possible in more traditional educational settings, while also engaging students in the examination of their own data. The blended environments may alter the structure and functioning of classrooms by changing how instructional activities are designed and delivered and by making the role of students more active participants in the teaching and learning process.

Blended and personalized learning have become topics of emphasis for policymakers. Personalized learning is seen as the customization of educational and instructional activities to address individual students' needs. Yet as Cavanagh (2014) notes, there still is no common definition despite the increasing discourse around personalized learning. A recent event, *Time to Act: Making Data Work for Students*, held by the Data Quality Campaign (2016) brought together policymakers, elected government officials, educators, civic leaders, and other interested stakeholders to discuss the role of data in improving education. At the heart of the discussion was personalized learning. Participants noted the importance of personalized learning environments, its technology, and the resulting data, to customize instruction and education to meet the needs of all students (Guidera, 2016; Holiday, 2016; Messer & Polis, 2016; Perdue, 2016). The speakers described the power of personalized learning: the provision for real-time data; the empowerment of teachers and students; immediate course corrections; the use of data to individualize for every student; and connectivity to reach all students regardless of circumstances. Guidera (2016) laid out several important points that pertain to the model of learning. First, education must make students the central focus. Data should be used to address the individual needs of each student. Second, the technology is not enough; the focus must be on the people, not the data systems or the technology. Third, education must move away from a compliance model and instead use data to improve the teaching and learning process. Fourth, there needs to be a culture of continuous improvement with the provision for the right data at the right level of granularity for the right solutions. Personalized and blended learning environments both have the capacity to address student needs if properly implemented.

Blended learning and personalized learning are often used interchangeably, although there are differences. Blended learning is a somewhat anomalous concept with differing definitions, differing terminology, and varying components. This report focuses on the term, blended learning because it melds the use of technology and data sources into the structure and functioning of the school and the classrooms. It is a hybrid model that combines the unique affordances of the technologies, yet provides the face-to-face interactions of brick and mortar schools and classrooms. Because of the technology infusion in blended learning, these environments are thought to provide more opportunities for new, diverse, and real-time data

[1] The authors wish to acknowledge the Bill and Melinda Gates Foundation for the support of this work. We would also like to acknowledge the administrators and teachers of the three Pima Prevention Partnership schools that participated in the study. In particular, a big thank you to the three principals, Lisa Long, Karmen Taravotti, and Michael Dunbar. The authors also wish to acknowledge Jason Feld and Nancy Auslander of ATI for providing invaluable information about the Galileo system.

collection, not possible without the technology. As such, these environments contain some of the customizable components of personalized learning (Bailey et al., 2015).

Research in the areas of blended and personalized learning has begun to emerge. In particular, the research reported here is informed by the work of Pane, Steiner, Baird, and Hamilton (2015) conducted at RAND Education. Using a multi-method approach, the RAND research identified five domains or topics and 13 attributes of personalized learning that inform the current work, particularly in interpreting the results.

- Learner Profiles
  - Personalized goals for students
  - Student data provided and discussed with students
- Personal Learning Path
  - Outside of school learning
  - Flexible/multiple paths for students through content
  - Individual student support
- Competency-Based Progression
  - Student progress through content based on competency
  - On-demand assessment to demonstrate competency
- Flexible Learning Environment
  - Student grouping
  - Learning space supports model
  - Structure of learning time
  - Extended learning time for students (extended school day or year)
  - Technology available to all students
- College and Career Readiness
  - Developing college/career preparation skills

RAND and WestEd researchers communicated about common interests so that both studies would be mutually informed. The RAND attributes were published after WestEd's data collection was completed thereby helping to inform the coding and analyses of the project's data sources.

The WestEd report includes a review of the existing literature and is intended to contextualize the case studies presented here in the broader landscape of blended learning research. To provide the needed context, this review examines the literature in terms of five topics:

- What is blended learning?
- What are the anticipated affordances or advantages of K-12 blended learning environments; what are the anticipated challenges; and what are the trends?
- What is the national context that influences blended learning?
- What does research tell us about blended learning implementation, particularly with regard to needs for, access to, and use of data to inform instruction?
- What does research tell us about outcomes for students in blended learning environments?

Because the field is still relatively new, rigorous research and evaluation of blended learning's K-12 implementation and outcomes are also relatively few. Most frequently cited research and evaluation on these topics are in the form of case studies, although the RAND study linked elements of personalized learning to student outcomes (Pane et al., 2015). This review examines a broad range of research on blended and personalized learning to provide an overview of what is known about K-12 blended or personalized learning environments for students, especially with regard to data use for informing instruction and learning. Although blended learning and personalized learning are not synonymous, they typically are conceptualized as comorbid types of learning. This report describes the terms below, and for the purposes of this document, it occasionally uses them interchangeably.

Key Questions About Blended Learning

What is Blended Learning?

Blended learning is commonly conceptualized as the combination of both face-to-face and online or digital learning environments intended to afford teachers and students flexible opportunities in instruction, application, learning, and assessment. Blended learning environments, also called hybrids, provide some degree of student control over pacing, learning trajectories, timing, and place of learning, and provide the opportunity for the inclusion of real-time data. The Clayton Christenson Institute for Disruptive Innovation[2] articulates four necessary components of blended learning (Staker & Horn, 2012):

- Teaching and learning occur within a formal education program (e.g., K-12 for a high school diploma or certificate);
- Online or digital delivery of content and instruction is a component of the program;
- Students have some level of control over instructional time, place, path, or pacing; and
- Part or all of the instruction is delivered away from home in a supervised, brick-and-mortar location.

Based on its research on the implementation of blended learning programs, the Christensen Institute developed a typology of blended learning models with differentiation based on when and under what circumstances instruction and learning occurs in online versus face-to-face environments. These models are: (a) *rotation*, in which students rotate, typically on a rather fixed schedule, between digital learning, small-group, full-group and other modalities; (b) *flex*, in which the majority of instruction occurs in a digital environment—with some offline activities and face-to-face support provided on a flexible, adaptive, as-needed basis; (c) *à la carte*, in which a student takes a course completely online with an online instructor, though the student may use computers at a brick-and-mortar school site where they take other traditional or blended courses; and (d) *enriched virtual*, in which a student takes a course primarily online, but must attend occasional face-to-face instruction with the teacher (Horn & Staker, 2014).

However, as the International Association for K-12 Online Learning (*i*NACOL)[3] explains, blended learning "is not teachers simply putting lesson plans online or content resources online" (Patrick, Kennedy, & Powell, 2013, p. 14). Instead, in blended learning environments,

> …it is the magic of optimizing the face-to-face classroom with instructional models for personalized learning for teachers using online learning modalities and advanced technologies to accelerate and improve individualized learning experiences for each and every student, with real-time data on exactly how well each student is progressing. (p. 15)

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[2] The Clayton Christensen Institute is a nonprofit, nonpartisan think tank that promotes improved education through "disruptive innovation" that makes products and services simple, convenient, accessible, and affordable (see www.christenseninstitute.org).

[3] iNACOL is an international nonprofit organization with the mission to support and transform K-12 education policy and practice to advance personalized, learner-centered, competency-based, blended and online learning (see www.inacol.org).

Therefore, blended learning is typically conceptualized as a form of instruction that provides—to varying degrees—individualized, differentiated, assisted, and personalized learning opportunities. *Individualized* refers to adjusting the pace of instruction according to students' individual readiness to learn; *differentiated* refers to the use of different instructional approaches according to student need while keeping learning goals the same; *assisted* refers to adjusting or accommodating instruction according to student need, ability, or disability; and *personalized* refers to all of the above, also including taking into account the learner's unique interests and abilities (Grant & Basye, 2014).

Affordances, Constraints, and Trends Pertaining to Blended Learning Environments

Affordances

Achieving the aims of personalized learning through blended learning is a formidable goal. To do so, *i*NACOL (Patrick et al., 2013) posits several affordances that should be incorporated into blended learning models' combined digital and face-to-face learning environments.

Highly personalized, customizable, and student-centered. The learning environment provides students some control over how they learn. Instruction is differentiated, pacing is flexible, and interventions and supports for students are available on demand and when needed. Learning environments should respond to each student's needs and interests, be developmentally appropriate, and be informed by data and based on the science of teaching and learning.

Competency-based and rigorous. Learning objectives are explicit, measurable, and align with standards of college and career readiness. Students should be able to demonstrate their mastery at any time, without having to adhere to a rigid instructional pacing schedule.

Data-driven. Instruction to facilitate student learning should be informed by frequent and varying forms of meaningful formative and summative assessments (e.g., embedded, performance-based, project-based, and portfolio). These data can be delivered in real-time. Additionally, other sources of diverse data are made possible. An essential component here is that the technologies provide both teachers and student access to a wide variety of data that are made possible by those applications.

Equitable and accessible. Students are afforded access to courses, experience, and teachers that they otherwise would not have (e.g., through remote communication such as video conferencing) as well as multiple methods of instruction and digital content. For example, online learning may benefit youth in areas with fewer opportunities to access high quality instructional supports, such as rural students or those with medically fragile conditions who learn from home (Aspen Institute Task Force on Learning and the Internet, 2014; Fernandez, Ferdig, Thompson, Schottke, & Black, 2016). At best, instructional methods are developed using research-based methods to meet the needs of learners with a range of abilities and disabilities, giving all students access to learning through multiple means of representation, expression, and engagement (Hashey & Stahl, 2014; Meyer, Rose & Gordon, 2013).

Staffed "flexibly" but capably. The way that teachers, outside experts, community resources, home mentors, online tutoring, and technical support are staffed permits instruction and learning to happen any time. Doing so requires opportunities for educators to build a common understanding of proficiency and effective communication about past and present learning data. The possibilities afforded by blended learning are stimulating growing interest in effectively using technology to support appropriate teaching, learning, and assessment environments. Toward this end, student information and competency-based assessment and learning management systems can provide relevant, easily accessible, and shared data to support students, teachers, and schools. With sophisticated tools, educators can harness information from a wide variety of sources, including from the "digital ocean" (DiCerbo & Behrens, 2014), to achieve the goals of personalized learning (Bienkowski, 2014; Bienkowski, Feng, & Means, 2012). For example, innovations in flexible learning technology aspire to incorporate information about individual students such as prior academics, prior and real-time cognition, on-task and perseverant behaviors, among other data to adjust digital learning environments for individual students (Abell, 2006; Fletcher, Scaffhauser, & Levin, 2012). Developing software that can do these things automatically can help offload a great deal of the work that typically falls on instructors' shoulders. Progress is being made in research on data analytics and instructional and assessment software that can provide an understanding of how a wealth of formative, real-time data about students' progress can inform instruction.

There are several key advantages here. First, teachers and students save time through the provision for access to data and resources that may or may not be available without the technology in a cost-effective manner. Second, the diversity of data provides teachers and students with data that might not be available in traditional classrooms. Third, the data arrive in real-time, providing a tighter feedback loop among instruction, assessment (or the like), data collection, data analyses, and result interpretation. This iterative cycle means that data collection and feedback are much more tightly woven to the teaching and learning process.

Constraints

The degree to which the affordances of blended learning can be attained likely varies considerably from school to school and even classroom to classroom. This may be due in part to variations in design, fidelity of implementation, and other environmental constraints. For example, educational leaders may have different goals with regard to the degree of personalization desired or the ways that technology and data will be used—and the learning environments they implement reflect these specific visions. Variations in blended learning's affordances also may be due to limitations or constraints imposed by a school system's existing infrastructure. Policy constraints; technology challenges; limitations of digital learning programs; and emerging teacher and student competencies are some of the issues that can impact implementation of blended learning. These constraints are described briefly below.

Policy challenges. Research has begun to attend to policy environments that may constrain or facilitate adoption and implementation of blended, online/digital, and personalized learning. These include, for example, changes to the requirements and structures of course in-seat time and state and district assessment schedules (Redding, 2016). In blended learning environments with a highly personalized learning structure, a student should be able to advance based on demonstrated mastery or competency. However, most school systems have not relinquished the concept of Carnegie units needed to earn a course credit toward high school graduation, defined by seat time or hours in class. The conventional model of advancement relies, in part, on pacing guides and fixed assessment schedules for courses. This means a student surging ahead may not have access to or may be discouraged from pursuing more advanced learning, especially if that learning is designated for a subsequent course. Conversely, a student who is struggling with key concepts may nonetheless be advanced to maintain the proscribed pace of the curriculum, exacerbating performance gaps over time. Maine, Oregon, New Hampshire, Iowa, and Ohio are among the pioneering states establishing competency based education systems relinquished from these time-bound constraints with some success (Freeland, 2014; Patrick & Sturgis, 2013; Wolk, 2015).

Technology challenges. Technology issues that impede data use in blended learning environments include challenges such as limited internet connectivity and broadband; difficulty obtaining sufficient computer hardware; and insufficient data and analytic systems for collecting, synthesizing, analyzing, and reporting student learning and other data. Not all communities and students have equal access to these technology infrastructures outside of or even in school, and the disadvantage of the "digital divide" is most apparent among those who live in or attend schools in economically distressed areas (Dolan, 2016). At an entry level, schools use technology in limited ways, such as for electronic gradebooks and tracking student demographic data, attendance, and credits (CCSSO, n.d.). Sophisticated content management systems, learning management systems, portfolio systems, data dashboards, and so on may not exist, and if they do, they are not likely to be fully integrated, accessible, or aligned. They may not be interoperable; that is, have the capacity to share data. At the most advanced levels, student-centered systems should be in place to assess learning, integrate data, produce data analyses, showcase authentic work, and manage learning and assessment resources adapted to personalized content. Establishing these basic infrastructures is no easy task, and most technology tools are used for more rudimentary management and resource sharing (CCSSO, n.d.). Some research indicates K-12 online and blended programs are not prepared for the collection and analysis of data required to inform instruction, and data from various digital learning management and data systems have proven difficult to manage and interpret (Ferdig & Cavanaugh, 2011).

Limitations of digital learning programs. Digital learning environments that lack coherence and fail to align with the school system's adopted curriculum standards can pose challenges to blended learning. "Off the shelf" digital instructional technology developed by third-party vendors, for example, may be designed to automatically adjust the content, order, and pacing of the learning environment for individual students according to built-in formative data analytics, but these adjustments may not necessarily match the school system's content standards, order, pacing, or desired rigor. The value of digital learning technologies relies, also, on their research-based design; however, there is some evidence that currently available digital curricula may not be better than what is found in printed textbooks (Choppin & Borys, 2016), and they may not be appropriately designed for or accessible to students with certain disabilities (Basham, Stahl, Ortiz, Rice & Smith, 2015; Smith, 2016). Other types of digital learning software may allow (or require) teachers or students themselves to adjust these features of the digital environment, in which case efficient and valid formative assessment systems aligned with the adopted standards are essential for informing these decisions. In instances when teachers are not provided with a fairly comprehensive set of digital curriculum materials at the outset and instead are asked to curate digital materials for personalized learning, "foraging" behaviors have been observed that may result in an instructional curriculum with diminished coherence (Selwyn, 2007).

Instructor and student competencies. Blended learning can be complex environments for educators to implement. They require a great deal of expertise in the content area, pedagogy, and management of the digital and face-to-face environments, as well as sophisticated use of data to drive students' learning (Kennedy & Archambault, 2013). Professional development may be required at the onset and in an ongoing way to address teachers' skills in these areas. With regard to students, blended environments may be an easy fit for learners who have experience and demonstrated competency with independent work. However, it is unlikely that all students enter blended learning with the requisite prior knowledge of the content area, skills for staying engaged, and metacognitive and self-monitoring skills to be able to succeed. Rather than assuming students enter the blended learning environment equally ready for success, some—or perhaps many—students may benefit from support with developing and applying these skills (Redding, 2016).

Trends

Although the history around blended learning is not particularly long, it is possible to discern patterns and trends that have been emerging as implementation and research are evolving. DreamBox (2014) identified 10 trends:

- The deeply student-centered learning experience;
- Soaring numbers of digital learners;
- Supporting standards and higher-order thinking skills;
- Realizing benefits for both students and teachers;
- Data-driven instruction to personalize learning;
- Personalized learning accompanied by a lean, blended, iterative approach;
- Productive gamification;
- The mobile world is where learners live now;
- Bring Your Own Device (BYOD) is here and key to active three-screen days; and
- More broadband please. (p. 3)

Some of these trends are more relevant to the work described here. For example, creating a student-centered environment requires more active engagement on the part of the learners. Similarly, a focus on higher-order skills requires students to engage in deeper cognitive activities with more creativity and less passive and rote learning. The engagement impacts not just students, but also affects the changing role of the teacher. Blended environments tend to be more active, both in the classrooms and with the opportunities for virtual connections. Blended environments also provide data that heretofore might not be readily collectable or available in real-time that allow for customizable teaching and learning experiences. Finally, with the proliferation of mobile devices, emerging technologies, and more ubiquitous connectivity, blended environments provide for more flexibility throughout the teaching and learning process.

Blended Learning in the National Context

When the U. S. Department of Education (2016) released its most recent national education technology plan, blended learning and related components loomed large. The plan was divided into five sections – Learning, Teaching, Leadership, Assessment, and Infrastructure – that play an important role in the implementation of blended learning. The plan emphasizes the role of technology in the design of teaching and learning activities and notes that:

> Teachers collaborate to make instructional decisions based on a diverse data set, including student and teacher observations and reflections, student work, formative and summative assessment results, and data from analytics embedded within learning activities and software aided by real-time availability of data and visualizations, such as information dashboards. (p. 41)

The plan also emphasizes the role of technology for assessment, providing new and more innovative means by which to measure student learning. The plan lays out that the next generation of assessments will be: embedded in learning, universally designed, adaptive to learners' ability and knowledge, with feedback given in real time, and with enhanced item types that can measure complex competencies. Embedded assessments that are technology-infused can provide real-time data and immediate feedback. Whether through assessment platforms or data dashboards, such data have the potential to provide more meaningful and timely information to students and teachers about learning progressions. And the data will be more diverse, in-depth, and informative for the teaching and learning process. In combination, the diverse data and the immediacy of feedback, will enable more highly adaptive learning experiences made possible by the technology.

Recognizing that the current state of data systems makes interoperability a challenging prospect at best, the plan stresses the need to overcome this issue so that data from multiple sources, including formative and summative assessments, can reside in one repository. The single silo will facilitate easier access for teachers, students, data teams, and administrators. It will enable the triangulation among diverse sources of data to obtain a more comprehensive picture of the students.

Having the technology infrastructure in place is important, but so too is the provision for the human infrastructure; that is, that educators must know how to use the data effectively and responsibly (Data Quality Campaign, 2014; Mandinach & Gummer, 2016). They must be data literate. Having the students also involved in the examination of data also is a recommendation posed by the Practice Guide on data-driven decision making released by the Institute of Education Sciences (Hamilton, Halverson, Jackson, Mandinach, Supovitz, & Wayman, 2009).

Implementation Research

Because the field of blended learning in K-12 environments is relatively new, its research and evidence base is also emerging. In almost all the existing implementation studies, the districts and schools under investigation were themselves new to blended learning, innovating, and evolving at a rapid pace. Therefore, because of blended learning's relative newness in K-12 settings, the field does not yet have information about what longstanding, established, stable and sustainable models might look like. Available studies focus on a variety of implementation issues, ranging, for example, from district level leadership and organizational, administrative structures that support it; to financial models; to instructional issues; classroom management and even physical arrangement of students. Three studies of blended learning implementation are highlighted here. They attend to how instructional decisions are made in blended learning environments, in particular to how data are used. These studies were chosen because they inform the field about key components for effective or less effective implementation and as related directly to the research findings reported here.

RAND Studies

RAND conducted a study of 32 Next Generation Learning Challenges (NGLC)[4] schools that were innovating and implementing personalized learning environments—most with blended

[4] NGLC was founded in 2010 by EDUCAUSE in partnership with the Council of Chief State School Officer (CCSSO), the International Association for K-12 Online Learning (iNACOL), the League for Innovation in the Community College, and the Bill & Melinda Gates Foundation (see http://nextgenlearning.org). EDUCAUSE is a

learning components (Pane et al., 2015). The implementation study included schools serving mostly urban, minority students from low-income families in a variety of grade level configurations (Pre-K-5, K-8, 6-8, and 9-12).

The study found more than three quarters of the schools were implementing some degree of flexible or "multiple paths" to progress through course content, typically as students rotated through small group, large group, and independent work within a classroom. Much of the instructional time was "technology-led" or "technology-facilitated." Ways technology was used, however, varied widely, with half or more teachers reporting its use for routine tasks such as reading, watching videos, using online reference materials, and using structured curriculum materials. Fewer, about a third or less, reported using technology for more complex tasks such as solving problems, collaborating with other students, or using adaptive learning software for problem-solving and adjusting parameters of simulations.

Several challenges emerged with the implementation of personalized learning. Flexibility with students' pacing and advancement according to mastery was reportedly hindered by constraints such as the perceived need to emphasize grade-level content and the desire to ensure students were making progress toward grade level standards through traditional accountability systems and metrics such as course completion and standardized testing. Schools that did not organize students by traditional grade levels and that were not constrained by these accountability systems were more likely to implement flexible pacing and advancement.

Overall, teachers in the NGLC schools were implementing various features of personalized, blended learning, and used data to do so. Compared with teachers from more traditional schools serving similar students, teachers in NGLC schools were more likely to report their data and data systems were of high quality and useful. They also were more likely to report they used a variety of data and data sources to understand student progress and inform instructional decisions. NGLC teachers reported that they had access to relevant information from tests, quizzes, and projects as well as non-achievement data. Over half of the teachers reported that they used data such as these at least weekly to identify each of the following: which students had attained mastery, which students mastered specific content or skills, and which students needed additional help. However, although teachers said they had access to a great deal of student data, 61 percent said they needed help applying this information to instruction.

SRI Studies

SRI and FSG conducted an extensive series of implementation studies (Bernatek, Cohen, Hanlon & Wilka, 2012c; Murphy, Snow, Mislevy, Gallagher, Krumm, & Wei, 2014). This study series examined implementation and outcomes of five charter management organizations (CMOs) overseeing schools with a range of grade level configurations (K-1, K-5, K-8, and grades 9 and 10). In these CMOs, typically, students rotated from digital learning at in-class or computer-lab stations to face-to-face small instructional groups led by a classroom instructor and other independent learning stations. In this way, students in the digital environment were not far from live, personal support when needed.

Instructors across sites articulated needs for digital learning programs offering a combination of features, including:

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nonprofit association whose mission is to advance higher education through innovative use of information technology (see http://www.educause.edu).

- Comprehensive and aligned with Common Core standards;
- Adaptive, meaning they were programmed to adjust automatically to students' progress and needs;
- Were "assignable," meaning the teacher could make adjustments to the content, level, or sequence of the program for each student;
- Provided valid reports of student engagement and learning, including daily formative, interim, and summative reports mapped to standards; and
- Allowed student data to be integrated into the school's data system for easy access and use, particularly when multiple programs were used.

The study noted that educators typically underutilized student performance data from online programs to inform instructional decisions, in part because the instructional software programs, provided by outside vendors, did not offer all of these features. For example, software programs' data dashboards were not integrated into the school's larger data system, a challenge further exacerbated when performance measures, progress measures, and dashboard data were not aligned with the content standards that the schools used. In some cases, educators questioned the validity of what should have been very useful formative data provided by the digital instructional programs, so teachers turned to their own formative assessments to measure student progress and mastery. The vast majority of teachers surveyed across all five CMO sites reported it was "very important" to receive proper training on accessing and interpreting student progress reports provided by the online instructional programs and using it to inform their instruction.

Data use may be enhanced by blended learning environments, a focus of particular importance to work reported here, Yet Murphy and colleagues (2014) noted a number of factors that impeded the use of data in the blended learning environments they examined. The study found that the technology-generated data were not well used. This finding might be due to the quality of the data dashboards, poor accessibility, the difficulty in interpreting the data, a lack of alignment of the data to the standards and curricula, and a lack of trust in the data. A major impediment seemed to be a lack of interoperability among diverse sources of data, making it difficult for teachers to triangulate among these silos of data. Time was also an impediment. Teachers simply did not have the time to examine the data in depth.

Despite the impediments around the data, the study reported benefits to the teaching and learning process. Teachers were able to customize learning opportunities for the students, particularly those most in need. The teachers used adaptive online materials, self-paced programs, and small group instruction.

Bingham Study

Most recently, Bingham (2016) conducted a qualitative study of a blended learning charter high school in a large urban area that served primarily low income and minority students. Data collection focused on the inaugural cohort of ninth graders and their instructors and school leaders. The intention was for students to progress through courses at their own pace, engaging primarily with the digital curriculum, and asking for help with on-site teachers when needed. Coursework was to be accelerated when the student demonstrated mastery, or slowed down to fill in necessary gaps of knowledge and skill. The vision was that teachers would serve as facilitators and coaches, providing targeted support to individuals or groups as needed. To free up teachers for their new role as facilitators and coaches in the classroom, the selected digital curriculum was to readily provide a range of learning activities, and was to perform most of the work of assessing student progress and mastery.

In contrast to this vision, Bingham observed the digital curriculum did not meet instructional and assessment expectations for a variety of reasons, such as leaders' and teachers' insufficient instructional planning, organization, and management of blended learning classrooms. The digital curriculum did not offer and adjust to the full range of students' needs, particularly those who did not have necessary skills or knowledge such as vocabulary and reading to work independently with the digital curriculum. In some cases, the curriculum was not rigorous enough. Consequently, "teachers could neither rely on the digital curriculum to provide students with opportunities to learn the material nor expect the information provided by the digital curriculum to be accurate" (p. 20). To cope with the demands of individualizing and personalizing students' learning environments, teachers felt they were "drowning digitally," and almost all returned to low-tech strategies for instruction and assessment. By the end of the year, classrooms looked more like traditional classes than the intended innovative, blended and individualized learning environment that was intended. The study concluded that "if an online curriculum is expected to bear the responsibility of assessment and data production, the online curriculum must first be vetted to ensure the assessments are rigorous and the data is accurate" (p. 27).

Outcomes Research

Research on the outcomes of K-12 blended learning environments, particularly rigorous, independent, peer-reviewed research, is scarce (Cole, Kemple & Segeritz., 2012; Means, Toyama, Murphy, & Bakia, 2013). The results are quite mixed. A small number of studies find positive impacts of specific formats of online learning, especially when it promotes collaboration and self-reflection among students (Bakia, Shear, Toyama & Lasseter, 2012). Female students were found to have improved math knowledge and problem-solving ability after engaging in digital mathematics instruction (Arroyo, Burleson, Tai, Muldner, & Woolf, 2013). Other researchers found a blend of online and school-based instruction is more successful in improving student outcomes than an online-only model (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Means et al., 2013) and work "marginally better" than traditional classroom instructional models (Bernard et al., 2014). Other research finds blended learning has neutral or negative effect on student achievement (Cole et al., 2012; Margolin, Kieldon, Williams, & Schmidt, 2011). Typically, authors cautioned that the reasons for the findings were unclear.

At this time, few research results from outcomes evaluation and research are available to inform best practices. Some of the challenges with conducting rigorous outcomes research in this area include:

- The great variation in instructional models, use of digital learning software, nature of face-to-face learning, degree of personalization, content areas, and special populations (e.g., students at risk of failure; returning drop outs; students with disabilities; and advanced, accelerated learners (Bernard, et al, 2014; Lowes, 2014);
- Identifying the appropriate comparison group, because almost all traditional classrooms now incorporate some type and degree of digital learning, and almost all online-courses also incorporate interaction and assistance from an instructor even if that instructor is distal rather than face-to-face (Lowes, 2014); and

- Challenges in conducting experimental design studies, given the organizational constraints of states, districts, and schools implementing blended learning and other learning environments (Lowes, 2014).

The outcomes analysis of the RAND study is one of the first of its kind to offer a comparison group analysis of student achievement outcomes in blended and personalize learning programs implemented at scale (Pane et al., 2015). Analyses found that, overall, students in 62 "personalized learning schools" performed .27 standard deviations higher in mathematics and 0.19 standard deviations higher in reading on Measures of Academic Progress (MAP) assessments compared with students in a matched sample. However, effect sizes varied considerably across schools. The nature of "individualized learning" also varied considerably among schools, and analyses of certain instructional components suggested that two out of three components were present in schools with the highest effect sizes:

- students were placed into flexible groups based on data;
- student learning spaces were supportive of personalized learning; and/or
- students were included in data based decision-making for learning.

Due to limitations in the design of the study, authors have been cautious about generalizing these findings to other blended learning environments.

In sum, research on K-12 blended learning and personalized learning environments may offer its greatest insights when it answers "*Under what conditions* does blended/personalized learning work?" (Ferdig & Kennedy, 2014; Pytash & O'Byrne, 2014).

Methods

This study used a purposive sample of three charter schools from one CMO in Arizona. The Pima Prevention Partnership is comprised of one high school in Phoenix, the Arizona Collegiate High School, and a high school and middle school in Tucson, the Pima Partnership High School and the Pima Partnership Academy. These three schools serve highly challenged youth and their families.

The Pima Partnership Academy serves over 100 students in grades 6 through 8. The Pima Partnership High School serves up to 280 students in the Tucson area. The Arizona Collegiate High School serves roughly 200 students in the Phoenix area and is designed as a college preparatory institution.

These schools were targeted because of their history of infusing diverse technological applications into their educational solutions to reach the challenged students. The schools also have strong building leadership focused on the use of technology and data to support teaching and learning, reflecting the recommendations from the Institute of Education Sciences practice guide on data-driven decision making (Hamilton et al., 2009).

The study focused on a core sample of teachers in each of the schools where the study tried to maintain continuity over two years to mitigate the teachers' level of mobility. The study also included building administrators who provide strong leadership in terms of technology infusion, data use, professional development, and a commitment to enhance teaching and learning.
The study used multiple measures to triangulate data sources. The measures included interviews with teachers and administrators, a survey, multiple classroom observations, an artifact protocol, and a data literacy protocol. Each of these measures focused on the collection of data to address the following:

- What are the technological applications being used in the classroom, the school, and through mobile technologies to enhance teaching and learning?
- What are the affordances of these technologies that provide data to teachers and students to enhance teaching and learning? Are these data unique to the technological applications or are they readily available without the technology?
- What other resources or artifacts do teachers use to enhance their instruction and classroom practices?
- What are the supportive resources provided by the school administration to make possible the blended learning environments?

Data were collected over a two-year period with several visits to the schools. During that time, the schools had experienced some turnover in the teaching staffs so additional teachers were added to the sample.

Results

Results from the multiple sources of data collection – interviews, artifact protocol, classroom observations, data literacy protocol, and survey - are reported based on the specific method. A topical discussion will follow in the concluding section.

Interviews

Interviews were conducted with all participating teachers and administrators from the three schools during the first site visit. As new teachers joined the sample, interviews were conducted with them. A second set of interviews was conducted with the teachers on the final site visit to discuss progress and changes over the course of the two academic years. The interviews were conducted in a semi-structured format, meaning that although there were specific questions to address, the protocol allowed some flexibility for modifications based on prior responses. The overarching topics included: blended and personalized learning environments, technology, data sources, teachers' backgrounds, data use and beliefs, and information about the school and its support structures. The interview protocol can be found in Appendix A.

Administrator Interviews and School Overviews

The students served by the Pima Prevention Partnership are primarily Hispanic and African-American. Most students come from impoverished homes. Some students are in a group or custodial home. Over 90 percent are on free or reduced lunch programs. Many students have attendance issues due to long commutes. The students may also lack supportive home environments, with parents tending to not be engaged in their children's education. Because of the challenged population, the explicit vision for all educators is respect for student needs. Socio-emotional and coping skills loom large. Educators hold high expectations for all students and strive to have them attain college. They do this through a nurturing and flexible environment that attempts to customize to the evolving needs of the students. Technology plays a major role in the customization.

According to the three principals, Pima Prevention Partnership has made technology integration a top priority for all of the schools. The use of technology is seen as a way to bridge the gap to deal with relevance because the students have all grown up with technology. The educators are using technology to provide resources to meet the needs of the students. For example, there are some classroom sets of books, but much more use of online books. Spanish books are available online. These books use the affordances of the technology through video and the audio and are viewed as more engaging media. In some sense and to some of the students, the technology may be considered Edutainment, because the students have to be entertained to be engaged. Administrators do not believe that this takes away from the education value. They use technology to supplement and enhance, not supplant instruction.

Because the students served by the three schools come from challenged environments, the educators must find creative ways to engage and keep the students from dropping out. For one of the high schools, the graduation rate has progressed from 24 percent to 36 percent, and then to 50 percent. Students were at 6th grade math and 4th grade reading levels, but the administration recognized that it will take time and effort to fill in the gap. Half the high school's population is over 18, with a very high mobility rate and a low average daily membership. Yet the administration plans to remain resolute about maintaining high but realistic expectations. According to the principal, “If you drop the bar, you are not helping the kid.”

They see leveraged technology as a way to bridge the gap. They use various technologies to enable students to be connected from any where at any time. The technologies are diverse. All classrooms have Smartboards, projectors, COWs (computers on wheels – 30 notebooks), laptops, responders/clickers, graphing calculators, and smart tablets. They use some of the state technology, including ADE Connect and AZDash to provide a different level of data. They use the Galileo assessment system from Assessment Technology Incorporated (ATI) to provide formative assessments and to have teachers and students examine test results. This helps to engage students in data conversations. Students are expected to accept responsibility for their own learning. Students are also expected to plot their own data and monitor their progress, understanding what they need to do to improve. The philosophy is that data drive the discussions.

Accodring to one principal, “If you drop the bar, you are not helping the kid.”

The administrations provide many resources for teacher professional development around instruction, curricula, data, and technology. They bring in professional development providers on a regular basis, send teachers to conferences as needed, and provide professional development on Wednesday afternoons, where technology and data use are expected.

The schools use non-test data to evaluate teachers. Because the attendance rate sometimes falls below 50 percent, the administration believes that you cannot define a teacher when kids are not in class. Students come from a 50-mile radius to the campuses, causing a host of realistic problems. Transportation is a financial and logistic problem so they provide students with public transportation passes. The Partnership realizes that the families care about the kids but circumstances are challenging so the Partnership tries to help the families in any possible way and to create opportunities for the students to stay in school. Although the majority of the students have Internet access through a cell phone, programs are designed so that they can stay on campus to get their work done. Most students do not have a home environment that promotes learning so homework is about learning and mastering the standards. Faculty members stay late to work with the students. There is a conscious effort for teachers to model good behavior and ethics. The result is that the schools have moved from a state grade of D, to a C in Year 2, and to a B in Year 3.

The schools try and recruit data and technologically savvy teachers and then provide resources to create a community around data and technology use through data teaming and professional learning communities. Two hours each week are devoted to teaming and to professional development.

The schools now have a robust data collection system and process. There is a center server and data system, yet there are still data silos given the diversity of technological applications. The principals are all data savvy and are constantly working to improve the technological and human capacity of their staffs. There is one central “data guy” that serves all three schools. He is the go-to person for all things data-related. He handles data from Galileo as well as the changing landscape of testing in Arizona (from AIMS, to AZMerits, and now to local control of testing). Data are collected through Galileo, the state system, SchoolMaster, Gradebook, AZDash, and other applications. Diverse data are collected, not just student performance: family contact information, medical (vaccination, special needs), attendance, tardiness, early dismissal, transcripts, missing assignments, grades, languages, family circumstances, growth reports, and other data. There is a FamilyLink for families and students to gain access to the system.

Most staff have more than a passing knowledge of data and technology, due in a large part because of extensive professional development opportunities. Yet, because of teacher mobility due to the intense and demanding environment, there is a constant need for more professional development, particularly for newer staff. Administrators are seen as highly supportive of teacher needs in terms of training, professional development, and the provision for resources.

Teacher Interviews

The teacher interviews yielded information about four general topical areas: teacher background and their beliefs around technology and data use; components of blended learning environments; technology; and data use.

Teacher Background

The sample of teachers ranged from fairly new teachers (second year teaching) in the first year of the project to experienced ones (22 years). The average number of years taught was 9.5. One teacher had come from industry, another was alternatively certified through Teach For America, and another was trained internationally (the UK).

All but two of the teachers reported having received training in the technologies used in their schools and around data use. The technology vendors provided targeted training on the use of the Smartboards and the Galileo assessment system. The Arizona Department of Education provided training on their data system applications. All but one of the teachers reported that professional development, conference attendance, and other learning opportunities abounded for them. WestEd provided professional development on a variety of topics.

In terms of their beliefs, all of the teachers reported that they believed that using data has the potential to improve instructional practice and help to meet their students' needs. They all recognized the importance of data and provided rationales for how data can be used effectively in their practice. A number of teachers mentioned that the use of data helps them to consider what to teach, what to reteach, and allows them to plan their instruction. Several teachers commented that data drives decisions and their practice must be grounded in data. One teacher commented that data must be more than standardized tests because they are consumed by these results. Another teacher noted the importance of needed diverse data and multiple data points. Some teachers focused on the challenged group of students they teach and how data use allows them to focus on the whole child, fills in the gaps from solely looking at test results, and provides a sense of responsibility and pride in meeting the diverse needs of their students. Data tell the teachers where to go and what gaps need to be addressed. Two teachers also mentioned the need to involve the students in their own data use. The take-away message was that the teachers could not meet the needs of the students without data and the technologies made possible teacher and student data use.

One teacher commented, "Data must be more than standardized tests… we are consumed by these results."

When asked about data literacy, most teachers considered themselves to be data literate. Two teachers thought they were not data literate and one was unsure. Many reported that they were but were constantly improving to be more data literate. When asked if they have ever taken a course on data use, four said yes. One was the internationally trained teacher; one noted a statistics course; one took a graduate level course; the other noted the assessment course. When asked to identify data literacy skills, the teachers' responses were quite varied and telling. Some were articulate whereas others seemed unclear. Many focused on the interpretation of data in terms of their instructional practice. Table 1 provides some of the responses.

Table 1.
Teachers' Responses: Identifying Data Literacy Skills

Adjusting and monitoring instruction	Modifying instructional plans
Determining if students meet the standards	Statistical awareness
Diagnosing	Synthesizing different data
How to collect data	Understanding bad data
How to filter what data mean	Understanding patterns
How to know where the kids are	Understanding what data mean
How to mine data	Using email
How to query data	Using formative and summative assessments
Hot to read data	Using historical data
Knowing what I do with the data	Using multiple assessments
Looking at more than snapshot data	Using qualitative and quantitative data

It is clear from these responses that some teachers have at least a basic understanding of some of the skills of data literacy (Gummer & Mandinach, 2015; Mandinach & Gummer, 2016), whereas others struggled with the concept. However, the list is only a subset of the skills and knowledge needed to use data effectively.

Blended Learning Environments

Two key components to the effectiveness of the blended learning environments observed in the three Pima Prevention Partnership schools were the explicit visions for the use of technology and data, and the strong leadership to support the environments. Every teacher noted that there was an explicit vision for the use of technology. The vision included innovation, meeting the needs of diverse learning through many media, getting technology in the hands of teachers and students to enhance the teaching and learning process, providing a supportive environment where everything is data-driven, and making the schools paperless. The foundational mission is to help all students to live to capacity and succeed. School leaders embrace the vision and model it to all staff and students.

Teachers were asked how their blended classrooms differ from more traditional ones and what the value-added is from these environments. All of the teachers mentioned that blended learning creates an environment that is more active and engaging for students and requires more hands-on activities. The environment seems to be less formal because it lends itself to more project-based and learner-centered activities. Teachers' notes that the blended environment gives these challenged students in particular access to a digital world to which they might not otherwise have access. It makes them digital citizens. It therefore has the capacity to level the playing field and provide a door to learning for even the most challenged students.

For teachers, the blended classroom provides significant time saving through the learning technologies, particularly the Galileo assessment system. Galileo provides immediate feedback to teachers and students that would not be possible without the technology, particularly in terms of the drill-down capacity for item analyses. It allows both teachers and students to know where students are in relation to state standards and helps the teachers to formulate and plan instruction. The data the system generates helps to drive instruction by providing information from which teachers can prioritize learning goals. The system produces understandable metrics and graphical displays of results and performance trends. It helps the students with self-monitoring skills as they map their learning progression and progress. The system can provide solid evidence of learning from reliable measures.

For teachers, the blended environment provides a great deal of flexibility in how to provide instruction. There can be individualization with a total customization to each student's needs. There can be small groups or full class instruction. The technologies allow teachers to know where each and all students are in terms of learning goals at all times. Student learning and growth can be monitored at global or fine-grained levels. This flexibility enables teachers to pinpoint students' strengths, weaknesses, and learning needs.

The blended environment stimulates better organizational skills and efficiency for both teachers and students through access to diverse data sources that inform the teaching and learning process. Regardless of discipline, the data provided by the technologies enables teachers and students to gauge learning progress through rapid or immediate feedback. Teachers report that classrooms are more flexible, rigorous, more visual, more research-oriented and project-based, and less paper-oriented. Teachers and students have any time and any where connectedness, allowing for extended hours for learning opportunities.

Teachers report that students feel safe in the blended classrooms. The technologies somehow remove a level of fear from the students, especially when they are working in peer groups. Teachers also report that there is an increase in student success and evidence of enhanced learning. Students are more involved and engaged, have a clear understanding of expectations, therefore can take ownership for their own learning.

Blended learning environments promote the use of diverse data because of the affordances of the technologies that might not be possible in more traditional educational settings. The affordances relate not only to the types of data but the feedback loop from which teachers and students are able to access the data. For example, The Galileo assessment system and the Smartboards provide quick turnaround data, data on which instructional modifications can be made almost in real-time. The immediacy of the feedback and the depth and breadth of the Galileo analytics through its drill-down capability are immense time savers for teachers. They provide reports and results that would take teachers hours to perform if they could perform such analyses at all. Teachers are also able to accumulate historical or longitudinal data to trace trends, patterns, and progress over time. As one teacher noted, "real-time data are powerful." These data help teachers to understand students' strengths, weaknesses, and misconceptions in a manner that yields diagnoses that can be translated into instructional modifications. The performance-based data help to guide instruction and allow teachers to know what to reteach.

As one teacher noted, "Real-time data are powerful." These data help teachers to understand students' strengths, weaknesses, and misconceptions.

Not to provide a skewed notion that all data are assessment or cognitive data, the teachers reported diverse data that are not necessarily yielded by Galileo. These include attendance, music performance and music theory, fitness and nutrition data, observational data, attitudes, absences, and demographics. There are other student performance data collected as well, those that are discipline-specific and linked to classroom activities, content-related data, state assessments, and other types of measures. The foundation of all these sources of data is that they provide an understanding of the students, along with data such as contextual data.

One of the components of blended learning environments is the changing role of the student. These environments place more responsibility on students for their own learning and monitoring their progress through self-examination of data. Essentially, students must become their own data-driven decision makers, one of the recommendations of the Institute of Education Sciences practice guide (Hamilton et al., 2009). Students must self-monitor. They look at their data and monitor their own performance. Because of this, students are more active, engaged, and motivated. They may even become competitive. They must take more responsibility and ownership for and pride in their own learning. Teachers report that many students are receptive to the process, whereas some are less so. Teachers also report that students grow to understand expectations by monitoring their progress. They gain time management skills and collaborative skills. One teacher uses a peer editing process that requires collaboration and trust. Students see their success and build on that progress. The process provides increased transparency around the expectations and standards. Teachers also report that the students feel safe in this environment. They help to guide one another. The increased responsibility applies beyond the boundaries of the school because of the mobile technologies. Students communicate with teachers and other students through social media, email, texts, and the instructional portals any time and any where.

Teachers report that students grow to understand expectations my monitoring their progress. They gain time management skills and collaborative skills.

One of the components of effective data use is for teachers to engage in collaborative inquiry through data teams and professional learning communities (Hamilton et al., 2009; Love, Stiles, Mundry, & DiRanna, 2008; Mandinach & Jackson, 2012). Each school had a math data team and a language arts data team. Teachers outside those disciplines also participated because of the way the curriculum was structured. For example, the science and history teachers used writing prompts that addressed certain standards. The music teacher in one of the high schools participated in both data teams because she taught the concept of fractions through musical notes and composition through required writing assignments.

The data teams met at least once a week, if not more. Wednesday afternoons had protected time for teachers to meet and discuss student data. Teachers would analyze data and examine student performance. They would note students who were struggling and those doing well. They would discuss deficiencies by drilling down into data. They would use a data dialogue process with guiding questions to structure their analyses. The teams would analyze lessons and determine what needed to be retaught and how the instruction needed to be modified. The teaming process was based on an open and constructive exchange of ideas in a non-judgmental environment.

Technologies

Technologies are a major component in blended learning environments. The three Pima Prevention Partnership schools most definitely had diverse technologies infused in the classrooms and even made some available through remote and mobile devices.
The schools were equipped with a multitude of technologies. Some technologies were classroom based, whereas others were mobile. There was an emphasis on mobile technologies to allow the students to have access any time and any where to instructional and assessment materials. Some technologies were discipline-specific whereas others were more generic. All classrooms were

outfitted with Smartboards, a computer for the teacher, a projection system, and classroom sets of laptops or tablets. The computers were stored in mobile containers called COWs or computers on wheels. WiFi was readily available throughout each campus, although one teacher noted that the bandwidth was insufficient for the demand. Other technologies included WiFi-enabled calculators, graphing calculators, student response systems, smart phones, laboratory equipment specific to the science courses, and electronic keyboards in the music rooms. Teachers used the Galileo formative assessment system, various applications provided by the Arizona Department of Education such as AZDash, videos, Apple TV, YouTube materials, Schoolology, notebook software, GradeMaster, Google Earth, Google Classroom, Kahoots, Garage Band, My Fitness PAC, PowerPoint, interactive journals, spreadsheets, and many other websites, software appropriate for their disciplines. Teachers also used text messaging, Facebook, and email to communicate with their students.

Below are some examples of the use of the applications.

- A music teacher used Garage Band for composition. She also used the electronic keyboards to record student performances and monitor progress from which she could diagnose issues and discuss them with students. This teacher also used videos to provide examples of musical expression.
- An English teacher had her students access websites to explore advertising campaigns, analyze messaging, and write about the findings.
- A science teacher used Google Earth to demonstrate aspects of ecology and earth science.
- Another science teacher used videos of animals and plants for biology and then concretized the videos with school trips to the zoo and botanical gardens.
- An English teacher used remote technologies to monitor students' performance on writing assignments, especially when absences rose.
- A business teacher used websites to have her students construct a marketing plan for a professional baseball team. She also used websites to simulate the job application process.
- A social studies teacher used Google Earth to examine the boundaries of countries.
- A math teacher used the Smartboard to collect student responses to a unit on measurement. He was able to examine individual student performance as well as the whole class to look for understanding and misconceptions.
- Many other teachers used the Smartboards for the same purpose – recording and analyzing student work, in English, music, social studies, science, math, and business.
- A physical education teacher used a fitness app to measure activity levels. She also used a nutrition app to help her students make better decisions about food choices.
- A math teacher used the student response system to engage students in a discussion about a unit on equations.
- A science teacher used social media to communicate with her students about a particular unit.

All of the teachers relied on the affordances of Galileo to provide real-time assessments that are linked to state standards. They commented on the expedience of turnaround time of the analyses and reporting and the system's deep item analyses and explicit graphical displays. They also commented that the system allowed teachers and students to monitor performance at a level that provided invaluable information about student successes and failures, understandings, and misconceptions.

The fact that each classroom had laptop computers or tablets in sufficient number for all students enabled teachers to use the Galileo system effectively as well as have students conduct research and online activities individually or in small groups as appropriate for the lesson.

One of the most essential affordances of the technologies was the data that the applications provided to teachers and students. A primary source was from Galileo, providing rich and multi-level formative assessment data almost instantaneously (see Appendix B). Teachers acknowledged that it would have been almost impossible for them to generate these data without spending significant amounts of time. Galileo provided item analyses down to the level of distractor analyses so that teachers could immediately identify student misconceptions. For teachers to do this without the technology would have been an onerous and labor intensive process. In addition to the real-time data and the immediacy of the analyses, Galileo also provided easily understandable tabulated results and reports aligned to state standards. Other teachers noted the diagnostic value to the data, not just from Galileo but other technologies. The Smartboards also enabled teachers to collect, record, and analyze student work products.

One of the most essential affordances of the technologies was the data that the applications provided to teachers and students.

One of the challenges to having so many technologies is the fact that they often work in isolation with limited interoperability. Indeed, this was the case across the three schools. Applications worked in isolation. Connections were rare and data sharing pretty much non-existent.

Data Sources and Use

Teachers were asked about their access to data and the sources of data they use. They all reported that they had access to many sources of data. They also noted that their schools had a "data guy" who was the go-to person for all things related to data. He would help them access data and help them with the data use process. Most of the teachers focused on the data from the Galileo assessment system, noting that without the system and its analytics, the data process would be impossible and too labor intensive.

Yet when asked about the kinds of data they use, teachers were clear that they used much more than assessment and student performance data. Some teachers mentioned the Galileo data, some mentioned state assessment data, but others identified motivational, perception, attendance, behavioral, observational, attitudinal (mood), physical, medical, group processes, background (family), demographic, and coping strategy data. It was clear, though, that the data from Galileo, and the system's ability to drill down to item analyses loomed large as a data source. Because of the frequent conflation between data literacy and assessment literacy (Mandinach & Gummer, 2016), teachers were asked specifically if data were only about assessments or data are broader. All teachers acknowledged the centrality of assessment data but also the need to consider the whole child, context, and background. The teachers were asked what they thought were the most important data. Responses were diverse, including cognitive, non-cognitive, and contextual data (see Table 2).

Table 2.
Reported Data as Important

Assessment (formative and others)	Interests
Attendance history	Living conditions
Background data	Observations
Confidence	Perception
Context	Progress over time
Home life	Trust
IEP's	Willingness to try

Yet even with the plethora of data available to them, the teachers acknowledged that there were data they would like to have. Many wanted historical or longitudinal data. They wanted more data on family issues and background (graduation history), arrest records, and background or contextual data to help them gain a more holistic understanding of their students. One teacher even mentioned that she wanted photos of each student. Another teacher connected with students through Facebook. Students followed the teacher's out of school activities and the teacher was able to learn a great deal about what is important in her students' lives. She was able to better contextualize her work with them by understanding home and personal environments

Teachers were asked if the data they currently have are sufficient for making decisions. They all said yes, but noted that there were other data that would be helpful. Some of the missing data were arrest records, data on family issues, emotional data, and data one teacher termed "intangible" (e.g., whether a student is having a bad day). All teachers reported that the data they have are actionable; that is, from those data, they can draw conclusions and make decisions. The data help them to determine students' understanding and misconceptions and what needs to be retaught.

Artifact Protocol

The Artifact Protocol was given to all teachers during their initial interview. It asked the teachers to identify the data they use in the course of their practice, the materials or resources they typically access, and the colleagues and specialists they consult about their instruction. Results reflect data from 14 teachers.

Teachers reported using diverse sources of data, with some being fairly universal. Assessment data are the most frequently used, followed by conversations with students, colleagues, and parents, classroom activities, observations, attendance, and behavior (see Table 3).

Table 3.
Number of Teachers Reporting Use of Types of Data

Type of Data	N	Type of Data	N
Summative data	14	Conversations with parents	10
Formative data	13	Student reports	9
Conversations with students	13	Other student work products	9
Quizzes	12	Attitudinal data	6
Class assignments	12	Medical data	6
Observational data	12	Demographic data	6
Attendance data	11	Interim data	4
State achievement data	11	Other:	
Conversations with colleagues	11	PLC	1
Behavior data	11	Student projects	1
Benchmark data	11		

Teachers reported that they use diverse materials and resources. These include research (10), public media (11), textbooks (9), and diagnostic materials (11). All but one teacher reported using a variety of websites. They consulted websites for their specific disciplines, assessment websites (such as the Arizona site AZDash and the formative assessment site, ATI-Online), social media, and professional websites. All respondents reported that they sought help from and consulted colleagues and other professionals. These included administrators, other teachers, the school "data guy", supervisors, former professors, WestEd (provider of technical assistance and professional development), the formative assessment professionals at ATI, colleagues at conferences, disciplinary specialists, and state data specialists through AZDash.

Classroom Observations

Classroom observations were conducted for all participating teachers. Some teachers were observed multiple times. The observations noted the classroom set up, forms of technologies in the classroom, media and resources use, type of classroom activities, number, composition, and grouping of students, and structure of the classroom.

All classes were small in terms of number of students. The largest class had 20 students, but most were 15 and under. Some classes even had 5 to 7 students. Given the demographics of the three schools, the student populations were diverse with a predominance of Hispanic and African American students.

Technology loomed large in all classrooms. Every room was outfitted with a SmartBoard, projection system, computers, laptops, and tablets. Other technology applications were used as needed, depending upon the discipline (e.g., lab equipment for science courses, synthesizers for music classes). All classrooms contain high-bandwidth WiFi.

Classrooms in the two high schools were set up around student groups to allow for maximum student interactions. Seating was in pods of students. These classrooms were centered around the use of the SmartBoards. In contrast, the classrooms in the middle school were set up more traditionally, in rows to accommodate the larger number of students. These classrooms also focused on the SmartBoards but also contained what were called "COWs" – computers on wheels. Each classroom had a large mobile container on wheels from which teachers would extract laptops or tablets to distribute to the students for personalized work.

Examples of Classroom Observations Using the Affordances of Blended Learning

Classroom observations yielded rich examples of how different teachers took advantage of the technologies to enhance the teaching and learning process. These examples illustrate that impact of the affordances of the technology.

- The music teacher in one of the high schools used the SmartBoard to show video clips of music from popular movies to illustrate the concept of leitmotif in music. Students had to name the song and the movie and discuss the theme of the music and the emotions the music conveyed. Students then worked on keyboards (individually or in pairs), linked to a central panel for the teacher to hear their performances based on their understanding of the lesson.
- The music teacher, although not working in a tested area, participated in data teams for language arts and math. She included lessons on notes to link to the concept of fractions for the math team. She asked students to write about their favorite composer or artist for the language arts data team.
- A high school math teacher taught a lesson on seriation. Students sat in small groups with tablets to work on the lesson. The teacher used the SmartBoard where students presented their work and defended their responses to the problem.
- A high school math teacher taught a lesson that required students to build a catapult. She brought in tools to help the students gain hands-on experience with the construction process, focusing on the underlying math concepts. This was a revision of an original lesson on the same math topic where she had presented the topic first, examined the student performance data, and determined that the students were struggling with the math. She then modified the order of the lesson to do the hands-on component first to concretize the concepts first, then followed by the math. Students were self-monitoring their progress through the hands-on component and through online assessments of the math topic, aligned to the state standards.
- A student approached a high school math teacher with his mobile device in hand. He proudly announced to the teacher that he had worked through 80 percent of the online assessment remotely from home the night before. The teacher had set a deadline for completion of the unit and the student was remotely working through the assessments and working with the teacher on an individual basis to meet the personalized timeline for mastery of the materials.
- A high school science teacher mixed instructional approaches on a biology topic. She provided selected video clips for the class to view. She called individual students to her computer console to review their progress on the unit. During this review, she retrieved each students' electronic portfolio of work to discuss what they had done well and topics that still needed attention. The teacher organized a sequence of class trips to local venues to strengthen their understanding of the biology content. These trips included the zoo and botanical gardens.
- A middle school social studies teacher conducted a lesson on income disparities in Middle Eastern countries. She provided a structured worksheet with questions for her students that helped to facilitate their online research on income. The students were required to access media from the specific countries to research topics such as average income and gender income disparity. Secondary sources were not allowed. The teacher then asked the class about their findings from their research, asked for the source of the

information, and engaged them in a discussion about income in the targeted countries in comparison to similar data from Arizona and the United States.

- A high school English teacher worked with her class on an exercise on advertising. Students were grouped together, using tablets, to research particular advertisements around which structured questions helped the students conduct their research. The groups conducted their research while the teacher moved from group to group, stimulating discussion about their findings. She then brought the class together for a full group discussion and presentation of group findings.
- A high school teacher discussed performance goals with a particular student. This student was particularly challenged because he has to take public transportation that requires two hours of commute time to get to school. This means he often misses his first period class and had to do the work remotely. The teacher worked with the student to ensure that he was on pace with the progression of work and that he has access to the materials and the assessments via the student's mobile device. The teacher notes, that without the mobile device access, this student would not be able to complete the course and graduate.
- A middle school physical education teacher covered a unit on nutrition and fitness. She had her students access a website that laid out the key principles of good nutrition and fitness. She had them download an app to calculate their activity relative to the principles. She discussed with the class dichotomies such as taking the stairs versus the elevator, eating grilled versus fried chicken, and eating at home versus eating out. The students charted their eating and exercise patterns over time and relate this to the key principles.
- A high school career and technical education teacher had her class prepare for a job fair and conduct a job search in another city. The learning objective was how to apply for a job in a service industry in a distant city. Students were required to research the available jobs in the city, the needed qualifications, and the application process. This required them to go online to various websites and accumulate information. Students worked individually but discussed their findings with a partner as if the partner were an interviewer. The class then came back together as students showed the product of their search and a cover letter for a job application.
- A middle school social studies teacher gave an online formative assessment to his students using the Galileo assessment system. Students had either laptop computers or tablets on their desks to take the assessment. The teacher's console showed students' responses as they were taking the test. The console showed a matrix of student by item, displayed down to the level or correct or incorrect responses and what distractor students had selected. The teacher was able to examine the matrix to determine how well the students understood the particular concept, linked to the state standards. He could tell which students were struggling, which students had mastered the concept, and which specific topics are causing the more learner difficulties. The teacher then reported to the class what needed to be retaught to the entire class and what needed to be a focus for particular students. He was able to discuss immediately with each student how they had done and what the next instructional steps would be. When asked later about the use of Galileo, the teacher admitted that he might be able to do the same sort of analyses without the technology but the construction of the assessment, the immediate logging of responses, the analyses, and the reporting resulted in significant time savings. He

estimated it would have taken him several hours to do what Galileo had done instantaneously.

- A high school career and technical education teacher worked with her students to develop and run the school store, based on principles from her business courses. This required students to understand the fundamental concept of supply and demand and use technology to monitor inventory and finance. Students, under the guidance of the teacher, collected data from the store, analyzed purchasing trends, determined pricing and restocking strategies, and ran the store as a successful technology-based enterprise.

Because Galileo was such an important tool across the observations and in the interviews with the teachers, ATI, the developer of Galileo has provided sample screenshots to illustrate what the teachers see, from which they can extract information about student performance, determine subsequent instructional steps, and stimulate performance discussions with students. See Appendix B for the screenshots.

The observations described above indicate that the affordances of the technologies in the blended learning environments were being used creatively and effectively to meet the individual needs of students and to customize instruction in ways to facilitate student learning. That said, there were observations where the classrooms looked no different than more traditional ones. Students sat in orderly rows. The teacher used a didactic, teacher-centered approach, and the use of technology was minimal. For the most part, however, the teachers in the three schools used the technologies available to them for planning, for instruction, and for assessment. Students used the mobile devices for remote learning and assessment, and for activities in the classroom. Teachers were able to monitor student performance and discuss results with the students to keep them on pace. Students were engaged in the performance conversations. Data were readily available to teachers and students that might have been impossible or impractical without the technologies.

Data Literacy Protocol

The data literacy protocol was developed to capture the skills, knowledge, and dispositions outlined by Mandinach and Gummer as they created the data literacy for teachers (DLFT) construct (Gummer & Mandinach, 2015; Mandinach & Gummer, 2016). The protocol was reflective of an intermediate version of the construct. Since the time of the developing and using the protocol, the construct has further evolved and skills and knowledge categorized in a modified manner (Mandinach & Gummer, 2016). The Protocol was aligned to the components of the DLFT construct with six skills related to the Identification of Problems of Classroom Practice, 21 skills related to Using Data, 14 to the Transformation of Data Into Information, nine to the Transformation of Information Into a Decision, seven to the Evaluation of the Outcomes of a Decision, and seven to Data-Related Habits of Mind. Given the construct, it was expected that some of these skills would be manifested in classroom practice and observable through classroom observations, whereas others might be implicit, exhibited during data teaming activities, or done outside of the classroom. Furthermore, whether or not the skills might be evident through observation may be dependent upon the classroom activities being observed at any given time. The results were expected to reflect those nuances.

Appendix C provides the data from the protocol and illustrates the components original coding under which the data skills and knowledge were categorized. Data were collected for 23 classroom observations, seven of which were repeated measures to determine consistency within a teacher. Results from the Protocol are presented in Table 4. The first column contains a list of the specific skills. The next column denotes the number of teachers who showed evidence of the skill during the observation. The third column indicates how many among the seven repeated observations showed consistency, either in the presence or absence of the skill during the observation.

As can be seen in Table 4, the range of observed skills is from 2 (determine unintended consequences) to 23 (monitor student progress). The most readily observable skills are included under the component, Transform Information into a Decision, the essential pedagogical component of DLFT. These are the skills that teachers use to impact instructional practice. The most frequently observed skills in this component include individualizing instruction, planning classroom practice, designing classroom practice, and implementing classroom practice (22 teachers). Almost all the teachers also showed evidence of articulating a problem of practice (22), monitoring classroom practice shifts, (22), using both formative and summative assessments (21), adapting current classroom practice based on immediate student feedback (21), incorporating student work as a data source (20), recognizing and using informal classroom information as a source of data (20), adjusting (slight change in method) classroom practice (20), and engaging students with their personal results (20).

The least frequent skills may be those that are not readily observable in classroom practice. They include: the ethical use of data (3); belief in data (4); comparing data pre- and post-decision (4); probing for causality (4); identifying inaccurate, misleading, or out-of-range data (4); prioritizing data (4); understanding basic statistics such as measures of central tendency and dispersion (5); using statistics (5); re-analyzing the original problem or decision (5); testing hypotheses (5); and considering the need for an iterative decision cycle (5).

In the case of multiple observations, there was much coherence within teachers of either showing evidence of specific skills or not using those skills. For example, all seven teachers showed consistency across the observations on: understanding the contextual issues at the student level; understanding the purposes of different sources of data; understanding what data are not applicable to the problem; integrating data sources; incorporating student work as a data source; recognizing and using informal classroom information as a data source; generating hypotheses; determining the next instructional steps; planning classroom practice; designing classroom practice; implementing classroom practice; monitoring for student progress; monitoring classroom practice shifts; analyzing relevant student work for evidence of changes in thinking; engaging students with their personal results; and the ethical use of data.

Table 4.
Results from the Data Literacy Protocol

Data Skill Knowledge	Teachers Observed Using Skill	Repeated Observations
Articulate the problem	22	6
Aware of student privacy	6	3
Understand contextual issues – student level	19	7
Understand contextual issues – school level	9	3
Involve stakeholders	11	6
Frame research questions	14	4
Understand applicable data	12	5
Identify possible data sources	12	6
Understand purposes of different data	11	7

Understand what data are not applicable	10	7
Access, retrieve data	11	4
Use multiple sources of data	16	5
Use qualitative and quantitative data	12	5
Understand data quality	6	5
Identify inaccurate data	4	6
Integrate data sources	9	7
Manipulate data	6	5
Examine data	11	4
Prioritize data	4	5
Organize data	6	5
Understand appropriate levels of data	13	4
Understand basic statistics	5	4
Recognize valid and reliable assessments	8	5
Use both formative and summative assessments	21	6
Incorporate student work as data source	20	7
Use technologies to support data use	19	4
Diagnose/identify student learning needs	19	6
Analyze data	16	5
Test assumptions	14	3
Generate hypotheses	16	7
Predict possible or likely consequences	6	6
Use statistics	5	5
Understand data displays and representations	9	4
Assess patterns and trends	8	6
Synthesize diverse data	8	5
Summarize data	6	5
Communicate about data	11	2
Interpret, make meaning	13	4
Draw inferences and conclusions	15	4
Probe for causality	4	1
Understand context for decision	15	5
Determine next steps	19	7
Individualize instruction	22	6
Differentiate classroom practice	18	5
Adjust classroom practice	20	5
Plan classroom practice	22	7
Design classroom practice	22	7
Implement classroom practice	21	6
Adjust current classroom practice	5	6
Re-analyze original problem or decision	5	5
Test hypotheses	22	7
Monitor classroom practice shifts	22	7
Monitor for student progress	23	7
Analyze relevant student work	19	7
Compare data pre- and post-decision	4	4
Determine unintended consequences	2	5
Consider need for iterative decision cycle	5	5
Engage students with personal results	20	7
Demonstrate ethical use of data	3	7
Demonstrate belief in data use	4	5

Think critically	7	3
Collaborate	9	1
Communicate with multiple audiences	12	6
Engage in continuous inquiry cycle	12	6

Survey Results

Teachers were asked to complete a survey during the first year of the data collection. The survey covered a number of topics that relate to school culture, technology, data, and leadership. The survey can be found in Appendix D.

Teacher Background Information

Fifteen teacher respondents completed the survey. Of the 15[5], there are five English language arts, reading, and/or writing teachers; five mathematics teachers; two science teachers; two social studies teachers; one visual or performing arts teacher; one physical education teacher; one career/technical education teacher; and two teachers categorized themselves as teaching other subjects. Respondents teach grade levels ranging from 6^{th} through 12^{th} grade: three teach 6^{th} grade, four teach 7^{th}, three teach 8^{th}, seven teach 9^{th}, nine teach 10^{th}, eight teach 11^{th}, and eight teach 12^{th}. Teaching experience ranges from one year to ten years or more. Seven teachers have three or fewer years of experience and eight teachers have more than three years of experience. Specifically, three teachers have one year of experience, two have two years, two have three years, one has four years, one has five years, one has six years, one has seven years, one has eight years, one has nine years, one has ten years, and one teacher has more than ten years of teaching experience.

Concerning teacher certification, 11 teachers hold a regular or standard certificate to teach in the state while four do not hold such a certificate and are also not currently enrolled in a certification program. To enter the education field, eight teachers completed an undergraduate teacher preparation program, three teachers completed a graduate teacher preparation program, one completed an alternate teacher preparation program (e.g., Teach For America or a program aimed at mid-career changes), two completed courses after attaining an undergraduate degree but not as part of a formalized graduate or alternative teacher program, one has not completed a formal preparation program, and one described his/her preparation as being described in another way but did not provide a description.

Teacher Views and Beliefs of Colleagues

Teachers largely hold favorable views of their colleagues' and administrators' efforts to support one another and focus on student learning. The majority of respondents agree that teacher colleagues collaborate with one another (12 of 15 teachers) and are highly focused on the mission of improving student learning (13 of 15 teachers). The majority of respondents agree that administrators at the school are highly supportive of teachers (13 of 15 teachers), are highly focused on student learning (11 of 15 teachers), and trust teachers to make decisions about their own instruction (13 of 15 teachers).

[5] Note that teachers may teach in more than one subject area or grade level so the numbers may total to more than 15.

Teacher Views of School Conditions That Promote Student Learning Through Technology

Teachers identified a select number of school conditions that serve as major obstacles to their efforts to promote student learning using technology. Nine teachers believe that students' inadequate technology skills serve as a minor obstacle to student learning, while six teachers believe this condition is not an obstacle. The majority of respondents (13 teachers) believe any limitations they might have regarding technology skills do not present an obstacle to student learning, while two teachers believe their limitations are a minor obstacle. Six teachers believe the lack of support from technology specialists or other staff who provide technical support is an obstacle to student learning, while the majority of respondents (nine teachers) believe this lack of support is not an obstacle.

Six teachers believe an inadequate number of computers and devices to accommodate all students is a problem within the school that affects student learning. Seven teachers believe a lack of devices is not an issue within the school and two teachers believe there to be a lack of devices for all students, but that this issue does not affect their learning. The majority of respondents (11 teachers) believe that a slow Internet connection and/or inadequate bandwidth is an obstacle within the school that effects student learning. Three other teachers believe the Internet to be slow and/or the bandwidth to be inadequate but do not believe this to be an obstacle to student learning. One teacher does not view the Internet connection and bandwidth to be an issue. The survey results conflict, to some degree, with the interviews and observations.

Four teachers believe they have had inadequate opportunities to participate in professional development related to technology use, which has been a minor obstacle to their efforts to promote student learning. Three teachers also believe there have been inadequate opportunities for professional development but do not believe this to have been an obstacle to student learning. Eight teachers do not believe the professional development opportunities related to technology use available to them have been inadequate. These results also conflict with the information yielded in the interviews where teachers reported a multitude of professional learning opportunities.

The majority of respondents (nine teachers) believe that problems with hardware have been obstacles to their efforts to promote student learning. Two teachers believe such problems exist but they do not hinder student learning. Four teachers do not believe there to be issues with hardware.

Teacher Views of School Conditions That Promote Blended Learning for Students

Generally, teachers have identified a select number of school conditions that serve as obstacles to their efforts to promote personalized learning for students. Five teachers believe a lack of support from school administration is an obstacle to their efforts to promote personalized learning for students. Four teachers believe there is a lack of support but do not view this to be an issue that hinders personalized learning for students. Six teachers do not believe a lack of support from administration is an issue within the school. These results are interesting because all interviews yielded reports of the supportiveness of school leaders around the implementation and use of technology but the survey may have identified shortcomings in the support for implementing personalized learning.

In terms of their own expertise, eight teachers believe they have a limited knowledge of how to effectively personalize instruction. For six teachers, this gap in knowledge serves as an obstacle to promoting personalized learning for students. Seven teachers believe they have adequate knowledge to effectively personalize learning.

The survey asked about class size and student load. The majority of respondents, nine teachers, do not believe their student load serves as an obstacle to promoting personalized learning. Six teachers believe they have too many students for whom they are responsible. For four teachers, their student load serves as an obstacle to promoting personalized learning.

Teachers report that differences in student performance levels within classes is problematic. Twelve teachers believe there is too much diversity in achievement levels among their students. For eight of these teachers, this variance serves as an obstacle to their efforts to promote personalized learning. Three teachers do not believe their students' achievement levels to be too diverse.

Accountability pressures seem to loom large for the three schools. The majority of respondents (11 teachers) believe they face pressure to cover specific material as a result of state or district standards and/or testing requirements. For nine of these teachers, this pressure is an obstacle to their efforts to promote personalized learning. Four teachers do not believe they face this pressure.

The majority of respondents (11 teachers) believe they spend excessive amounts of time developing personalized content for students. However, only five of these teachers believe the time needed to develop such content is an obstacle to promoting personalized learning. Four teachers do not believe they spend an excessive amount of time developing personalized content. Seven teachers believe they have inadequate data as they personalize students' instruction, and two of these teachers believe inadequate data is an obstacle to their efforts to personalize student learning. Eight teachers believe they have adequate data. Eleven teachers believe they have an inadequate amount of time to prepare personalized lessons for all students, with six of these teachers believing this inadequate amount of time to be an obstacle to their efforts to promote personalized learning. Eight teachers believe they have an adequate amount of time to prepare personalized lessons for all students.

Clearly absenteeism is a major issue in the schools given the student population. All teachers believe high levels of student absenteeism to be an obstacle to their efforts to promote personalized learning. Twelve teachers believe student absenteeism to be a major obstacle and three teachers believe it to be a minor obstacle. In addition to absenteeism, discipline is also an issue. All teachers believe high levels of student disciplinary problems exist within the school. Twelve of these teachers believe that student disciplinary problems present obstacles to their efforts to promote personalized learning for students. These results concur with the findings from administrator and teacher interviews.

Type and Frequency of Student Performance Information Received by Teachers

Teachers receive student performance information at varying levels of frequency. Some teachers receive certain information at least weekly while other teachers receive performance information a few times a year. Teachers responded to how often they receive: scores on assessments in mathematics or language arts; scores on assessments in subjects other than mathematics or language arts; student performance on specific concepts or skills; identification of specific students who need extra assistance; identification of specific students who have achieved mastery; and non-achievement outcomes (e.g., student behavior and attitudes).

Five teachers receive scores on assessments in mathematics or language arts at least weekly, seven receive this information at least monthly, and three teachers receive it a few times per year. Two teachers receive scores on assessments in subjects other than mathematics or language arts weekly, one receives this information monthly, eight teachers receive this information a few times per year, two receive it once per year, and two teachers never receive these scores. One teacher receives information about student performance on specific concepts or skills at least daily, five teachers receive this information at least weekly, five teachers receive it at least monthly, and four teachers receive this information a few times per year.

Six teachers receive notifications of the students who need extra assistance at least weekly, four teachers receive this information at least monthly, and five teachers receive it a few times per year. One teacher receives daily notifications of the students who have achieved mastery, five teachers receive this information at least weekly, three receive this information at least monthly, four teachers receive it a few times per year, and two teachers are never informed of the students who have achieved mastery. Four teachers receive weekly notifications of non-achievement outcomes, three teachers receive this information at least monthly, four teachers receive this information at least once per year, and four teachers never receive information of non-achievement outcomes.

Teacher Use of Student Achievement and Mastery Data

Student performance data of course are a major data source for all teachers, whether in traditional or blended environments. Generally, the Pima teachers use student achievement and mastery data for a variety of reasons. Ten teachers use student achievement and mastery data to tailor the pace of instruction to individual students' needs, while three teachers do not use data in this manner, and two teachers do not believe data is used to tailor instructional pace at the school. Ten teachers use student achievement and mastery data to tailor the content of instruction to individual students' needs, while two teachers do not use data for this purpose, and two teachers do not believe data are used to tailor instructional content at the school. Thirteen teachers use student achievement and mastery data to develop recommendations for tutoring or other educational support services for particular students, while one teacher does not use data for this purpose, and one teacher does not believe data is used to develop student support recommendations.

Fourteen teachers use student achievement and mastery data to identify topics requiring more or less emphasis in their instruction, while one teacher does not use data in this manner. Thirteen teachers use student achievement and mastery data to reflect on and discus teaching and learning with their colleagues, while two teachers do not believe data is used in this way at the school. Thirteen teachers use student achievement and mastery data to reflect on and discuss learning with their students, while one teacher does not use data for this purpose, and one teacher does not believe data is used to reflect and discuss with students at the school.

Teacher Use of Non-Achievement Data

Not all data that teachers use are solely achievement-oriented. Many other data sources exist. In the 2014-15 school year, five teachers reported using data on non-achievement outcomes (e.g., student behavior and attitudes), while ten teachers did not use this type of data. Of these five teachers using non-achievement outcomes: four use it to tailor the pave of instruction to individual students' needs; three use it to tailor the content of instruction to individual students' needs; all five use it to develop recommendations for tutoring or other support services for particular students; and three use it to reflect on and discuss learning with their students.

Teacher Reflections on the School Data Systems

Teacher beliefs and attitudes can be strong influences on their actual practice so the survey asked about their feelings toward the use of data systems. In general, teachers have favorable views of their school's data system. Ten teachers believe they have access to high-quality assessment data that help them adapt the pace or content of instruction to meet students' needs, while four teachers do not believe they have access to high-quality assessment data. Ten teachers believe the data system at the school provides real-time data that are actionable, while four teachers disagree. Ten teachers believe the school's data system provides information at a level of detail that helps them inform their instruction, while four teachers disagree. Eight teachers believe they have plenty of data but need help in figuring out how to translate the data into actionable steps. It is important to note that this is not a finding unique to the Pima schools as most professional development does not make the link between data use and actual instructional modifications (Mandinach & Gummer 2012, 2013, 2016).

Nine teachers believe it is easy to create custom assessments that evaluate what students are learning, while six teachers disagree. Nine teachers believe the school's data system is easy to use while five teachers disagree. Ten teachers report they can use the school's data system to easily produce reports they need, while four teachers are not able to easily use the system. Ten teachers believe the technology provides data that are not typically available without technology, while four teachers disagree.

Teacher capacity to use data systems and data more generally always is an issue, regardless of location (Mandinach & Gummer, 2012, 2016). Twelve teachers believe they have the necessary skills and experience to use data to guide their instruction, while two teachers disagree. One teacher did not find the questions on the school's data system applicable to his/her experience.

Teacher Data Sources and Frequency of Use

The survey asked about usage patterns and the sources of data that the teachers access. In general, data closer to the individual student and classroom level (e.g., attendance and personal data) are used more frequently by teachers than other forms of data (e.g., state data). Three teachers use state data at least weekly, two teachers use them monthly, and ten teachers use state data less than once a month. Four teachers use periodic data at least weekly, five teachers use them monthly, and six teachers use them less than once a month. Six teachers use local data at least weekly, one teacher uses them monthly, and eight teachers use local data less than once a month. Seven teachers use personal data at least weekly, three teachers use them monthly, and five teachers use the data less than once a month. Six teachers use behavior data at least weekly, four teachers use them monthly, and five teachers use behavior data less than once a month. Four teachers use medical data at least weekly and eleven teachers use them less than once a month. Nine teachers use attendance data at least weekly, four teachers use them monthly, and two teachers use them less than once a month. Eight teachers use attitude data at least weekly, two teachers use them monthly, and five teachers use attitude data less than once a month. Nine teachers use motivation data at least weekly and six teachers use them less than once a month.

Data Sources and Their Usefulness

Data will not necessarily be used unless educators perceive them to be useful. Utility can be a facilitator and a lack of perceived utility a major impediment. Table 5 represents the extent to which teachers reported the utility of different sources of data.

Table 5.
Teachers Find Several Data Sources Useful

Data Source	Yes (N)	No (N)
Attendance data	15	1
Attitude data	14	1
Behavior data	14	1
Medical data	14	1
Motivation data	14	1
Personal data	14	1
Local data	12	3
Periodic data	12	3
State data	12	3

State Data and Use

Data from state data systems often are seen as lacking local utility. The Arizona Department of Education has taken on a major system development effort to create data tools for the state's educators to provide them with real-time data. During the course of this project, the Department began rolling out some of the tools, though the effort is in its infancy. In general, state data is not used frequently throughout the school year. Two teachers use state data weekly to identify instructional content to use in class, seven teachers do so a few times a year, and three teachers use state data in this way one or two times a year. Two teachers use state data weekly to tailor instruction to individual students' needs, six teachers do so a few times a year, and four teachers use state data in this way one or two times a year. Two teachers use state data weekly to develop recommendations for additional instructional support, six teachers do so a few times a year and four teachers use state data in this way one or two times a year.

Two teachers use state data weekly to form small groups of students for targeted instruction, one teachers does this monthly, six teachers do so a few times a year, and three teachers use state data in this way one or two times a year. Two teachers discuss state data weekly with a parent or guardian, four teachers do so a few times a year, and six teachers use state data in this way one or two times a year. Two teachers meet with a specialist (e.g., an instructional coach or data coach) about state data on a weekly basis, one teacher meets with a specialist monthly, five teachers meet with a specialist a few times a year, and four teachers do so one or two times a year. Two teachers meet with another teacher about state data on a weekly basis, four teachers meet with another teacher monthly, four teachers meet a few times a year, and two teachers do so one or two times a year.

Local Data and Use

Local data typically have more utility at the school and classroom level. Yet among the Pima schools, the survey indicated that generally, local data are not used frequently by teachers. Four teachers use local data to identify instructional content to use in class on a weekly basis, five teachers use it once or twice a month, and two teachers do so less than once a month. Five teachers use local data to tailor instruction to individual students' needs on a weekly basis, four teachers use it once or twice a month, and two teachers do so less than once a month. Four teachers use local data to develop recommendations for additional instructional support on a weekly basis, five teachers use it once or twice a month, and two teachers do so less than once a month. Three teachers use local data to form small groups of students for targeted instruction on a weekly basis, six use it once or twice a month, and two teachers do so less than once a month.

Two teachers discuss local data with a parent or guardian on a weekly basis, two teachers do so once or twice per month, and seven teachers do so less than once a month. Four teachers discuss local data with a student on a weekly basis, four teachers have a discussion once or twice a month and three teachers do so less than once a month. Two teachers meet with a specialist about local data on a weekly basis, five teachers meet once or twice a month, and for teachers do so less than once a month. Five teachers meet with another teacher about local data on a weekly basis, four teachers meet once or twice a month, and two teachers do so less than once a month.

Teachers' Support in Use of State Achievement Data and Locally Developed Assessments

Teachers largely agree that they are supported in using state achievement data and locally developed assessments. Thirteen teachers believe they are adequately supported in the effective use of these data, while two teachers disagree. Twelve teachers believe they are adequately prepared to use these data, while three teachers disagree. Thirteen teachers believe there is someone who answers their questions about using the data, while two disagree. Eleven teachers believe there is someone who helps them change their practice based on these data, while four teachers disagree. Thirteen teachers believe the district provides enough professional development about data use, while two teachers disagree. Twelve teachers believe the district's professional development is useful for their learning about data use, while three teachers disagree.

The role of building leadership in data use is a well-established finding in the literature (Hamilton et al., 2009). Leadership in the Pima schools confirms that finding. All fifteen teachers believe the principal or assistant principal(s) encourages data use as a tool to support effective teaching. Fourteen teachers believe the principal or assistant principal(s) create many opportunities for teachers to use data, while one teacher disagrees. Twelve teachers believe the principal or assistant principal(s) has made sure teachers have plenty of training for data use, while three teachers disagree. Fourteen teachers believe the principal or assistant principal(s) are a good example of an effective data user, while one teacher disagrees. All fifteen teachers believe the principal or assistant principal(s) discusses data with them. Fourteen teachers believe the principal or assistant principal(s) creates protected time for using data, while one teacher disagrees.

School and District Provided Technology

As the Institute of Education Sciences practice guide on data use notes as one of the five recommendations of practice, having a school-wide or district-wide data system is essential (Hamilton et al., 2009). Through the project's observations, the Pima schools have substantial technology resources. Teachers largely agree that the programs, systems, and other technology provided by the district are useful. All fifteen teachers believe they have the proper technology to efficiently examine data. Fourteen teachers believe the computer systems in the district provide them with access to lots of data, while one teacher disagrees. Twelve teachers believe the computer systems for data use in the district are easy to use, while three teachers disagree. Twelve teachers believe the computer systems in the district allow them to examine various types of data at once, while three teachers disagree. Thirteen teachers believe the computer systems in the district generate displays and reports that are useful, while two teachers disagree.

Teacher Attitudes Toward Data Use

As noted above, teachers' attitudes of and proclivity toward data use are important to effective data use. In general, the Pima teachers are comfortable with their ability to use data. Twelve teachers believe they are good at using data to diagnose student learning needs, while three teachers disagree. Twelve teachers believe they are good at adjusting instruction based on data, while three teachers disagree. Thirteen teachers believe they are good at using data to plan lessons, while two teachers disagree. Twelve teachers believe they are good at using data to set student learning goals, while three teachers disagree.

Characteristics of the data systems can have an impact of teacher attitudes. Of the two major systems used in the Pima schools, Galileo is termed a formative assessment system that provides teachers with immediate data on teacher-constructed assessments. AZDash is a data dashboard being developed by the Arizona Department of Education to provide diverse data to educators. In general, the Galileo data system is found to be more informative than AZDash: Eight teachers report that Galileo is very informative, six teachers find it somewhat informative, and one teacher does not find it very informative; Four teachers report AZDash is very informative, eight teachers find it somewhat informative, and three teachers do not find it very informative. One teacher uses his/her own assessments due to not receiving training in either Galileo or AZDash.

Teacher Attitudes Toward Collaborative Teams

Most professional development and theoretical frameworks around data use focus on a model of collaborative inquiry carried out by data teams or professional learning communities (Hamilton et al., 2009; Love et al., 2008; Mandinach & Gummer, 2012, 2013, 2016; Mandinach & Jackson, 2012). In general, teachers hold positive attitudes toward their collaborative teams. Ten teachers believe members of their team trust one another, while five teachers disagree. Nine teachers believe it is okay to discuss feelings and worries with other members of the team, while six teachers disagree. Ten teachers believe members of the team respect those colleagues who are experts in their craft, while five teachers disagree. Thirteen teachers believe the principal or assistant principal(s) foster a trusting environment for discussing data in teams, while two teachers disagree.

Available Technologies and Their Usefulness

Generally, teachers report the available technologies in the schools to be useful in their classrooms. Eight teachers report the computers on wheels to be very useful, four teachers find them somewhat useful, and three teachers do not find them to be useful in the classroom. Five teachers report the tablets very useful, six teachers find them somewhat useful, and four teachers do not see them very useful in the classroom. Twelve teachers report that the Smartboards are very useful, while two teachers find them somewhat useful, and one teachers does not find them useful in the classroom. Twelve teachers report the Internet connectivity to be very useful and three teachers find it somewhat useful in the classroom. Six teachers report that the mobile devices (smart phones) are very useful in the classroom, four teachers find them to be somewhat useful, and five teachers do not find them useful in the classroom.

Discussion

It is clear from the multiple sources of results that teachers in the Pima Prevention Partnership schools are using the blended learning environments of richly infused technology and the resulting sources of data to reach a challenged population of students. This might not be done as effectively and efficiently if it were not for the affordances provided by the technologies used in the classrooms. Teachers and students have any time and any where access that allows them to extend and maximize learning opportunities. Teachers have in-depth item analyses linked to state standards to help them monitor student progress and plan instruction through their interactions with the Galileo system. Teachers report that the blended environment changes the structure and function of the classroom and the role of the student. Teachers also report that students are more active, engaged, motivated, and involved in their own learning.

Recalling the attributes that Pane and colleagues (2015) outlined for blended learning, all 13 components were observed in the three schools. The schools used *personalized goals* to structure the instructional plans for each student. The teachers and administrators used *student data* to inform instruction and discussed and involved the students in data-based discussions. The teachers across the two schools used a variety of data and resources to meet the needs of the students. The data were real-time, plentiful, and available at all times. The technologies used across the schools provided any time and any where access to *outside of school learning* opportunities. This meant that the schools provided out-of-school learning opportunities through their access to the technological platforms. The teachers *created flexible and multiple paths for students through content* materials by customizing the instruction to the individual needs of each student. Students worked at their own pace. They also provided *individualized student support*. The Galileo assessment system helped teachers to ensure that *students progressed through the content based on a competency* model. Galileo also provided *on-demand assessments* through which students were able to demonstrate competency of the domain, linked to the state standards, and provided teachers with real-time data that could immediately inform instructional planning. The teachers used different *grouping strategies* in a flexible way, aligned to the characteristics of particular units and lessons. The classrooms in the Pima schools provided *learning spaces* that supported the technologies and the diversity of learning objectives. Teachers used the affordances of the technologies to provide *flexible learning time* and *extended learning time* that often extended beyond the traditional and typical school hours in order to meet the needs of students' transportation schedules. Teachers stayed late to work with students and provided communication strategies after school hours to meet the needs of the students. *Technology was made available to all students*. In class, each student had a dedicated laptop or tablet. Finally, the two high schools in particular, sought to provide students with life skills and *college and career preparedness*. The Arizona Collegiate High School's vision included as an explicit goal to prepare its students for college. The Pima Partnership High School focused on career-ready skills through courses offered by the career and technical education teacher, whose courses emphasized job readiness.

Taking the RAND report's 13 attributes at face value, the Pima Prevention Partnership schools exhibited all of the components identified as important to blended learning environments. It is important to note, though, that these schools have characteristics that may not be readily generalizable. First, they are infused with many different technologies and teachers are well trained in how to use these applications. Second, one of the technologies, the Galileo assessment system, provides a rich source of real-time, student performance data that help teachers make rapid turnaround instructional decisions and modifications. Third, the leadership of the three schools have an explicit vision for student performance, using the technologies and data to undergird all teaching and learning activities as well as administrative decision making. These schools have extremely strong and dedicated leaders that help to provide a conducive and open context that promotes collaboration, respect, and trust among the educators. Fourth, there is no doubt that the educators in the schools recognize the importance of how the blended environments provide contexts that are sufficiently flexible and customizable to attempt to meet the many difficult challenges of their student population. The technologies provide the any time and any where extension beyond the brick and mortar of the physical school buildings.

In reviewing the characteristics of the Pima schools, it is important to note that the findings also are aligned to the five recommendations of the Institute of Education Science practice guide on data use (Hamilton et al., 2009). The first recommendation pertains to the use of an ongoing *inquiry cycle* to inform instruction. Clearly, the staff of these schools are identifying problems of practice, collecting data, and making decisions based on those data to inform their practice. The second recommendation is to *involve students in the examination of their own data*. Students in the three schools are taking an active role in being their own data-driven decision makers. Teachers work with them to set expectations and learning goals, and use data to monitor their progress to those learning objectives. The third recommendation is to establish a *vision for data use.* As noted above, the three building leaders explicitly lead with data. Their visions are well articulated and modeled for all to hear and see. The fourth recommendation is to *create a culture of data use* in the school. This means providing the necessary supports and resources for the establishment of a data culture. The schools have created data teams. There are dedicated times for the teams to meet. There is a "data guy" that helps all three schools with data-related issues and questions. School leaders make possible the time and resources for professional development, technical assistance, and attendance at relevant conferences and meetings. Finally, the fifth recommendation is to have a *data system*. The CMO has a central data system, but also uses other siloed applications, such as Galileo, that serve as repositories for data. Similar to the findings in other case studies (e.g., Bernatek, Cohen, Hanlon, & Wilka, 2012a, 2012b), the data systems lack interoperability and data sharing capacity, leaving each system to function in isolation. This is a very real issue due to the proliferation of diverse sources of data.

The current findings also reflect the work from the SRI study (Murphy et al., 2014) as they pertain to data use in blended environments. The SRI work noted the importance of data cultures. WestEd's work is in agreement. Whereas SRI noted that some online data were underutilized due to the quality of the data dashboards, WestEd found a strong emphasis on using online data, particularly from Galileo. The dashboards were an impediment, whereas Galileo was user-friendly and easily accessible. Galileo linked the data to state standards and produced interpretable data displays. Whereas data from SRI's dashboards did not provide a path to instructional steps, Galileo's results did. SRI mentioned a lack of trust in the online assessments. The Pima teachers did not convey any such level of doubt or mistrust of Galileo's data. Both the SRI and WestEd findings indicated that data sharing and interoperability of data systems are challenges.

Moreover, another challenge looms large which this work did not address but must be mentioned. As noted in this study, blended and personalized learning environments have the capacity to generate a plethora of data that can be accessible to teachers, students, and administrators. With the proliferation of data from diverse sources come concerns about the protection of data privacy. The collection and examination of these data sources, particularly in real time, provide for great opportunities for the customization of teaching and learning. Yet even greater challenges exist in terms of maintaining the safety and security of the data to protect students' privacy and confidentiality (Data Quality Campaign, 2016; Herold, 2014) and ensure that the educators are knowledgeable about how to use data not just effectively, but responsibly (Mandinach & Gummer, 2016). Data privacy and security have become key issues and must continue to be an area of focus.

Blended learning certainly has taken hold in the three Pima Prevention Partnership schools. These are small charter schools that serve a relatively small number of students. The question of the model's generalizability is of concern. More traditional schools are not likely to have the resources found in the Pima schools. They may have less technology. They may lack a vision for the use of technology and data. They may not have an embedded culture of data use and technology that extends within and beyond the school boundaries. They may not be provided with the extensive learning opportunities found in the Pima schools in terms of teacher professional development, technical assistance, and conference attendance. That said, there is much that can be learned from these three schools about how the alignment of RAND's 13 attributes (Pane et al., 2015) and the practice guide's five recommendations (Hamilton et al., 2009) in school settings can create blended or personalized learning environments that have the potential to reach even the most challenged students and help them to succeed.

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Appendices

Appendix A
Interview Protocol

Teacher
School

Items for Semi-Structured Interview Protocol

Blended Learning or Personalized Learning Environments

Can you describe how your classroom differs from one that might be considered more traditional?

What value-added has technology given in your classroom/school?

Does the blended learning environment provide data that might not be available in a more traditional setting?

What is the role of the student in this environment?

Do you use a model of collaborative inquiry in your classroom/school; that is; do you work with other teachers to examine data?

Does your school have a vision for data use? For the use of the technologies?

Does school leadership make it clear that using data is important? Using the technologies?

Technology

Can you please describe the technology that you have in your school/classroom?

Please elaborate on the data that the technology generate, provide access to, enable you to use?

Are the technologies connected in some way that there is data sharing across platforms?

Do these technologies provide you access to data that would not necessarily be available in a more traditional educational setting?

Data Sources

Can you please provide a description of the various forms of data you use in the classroom and with the technology to inform yourself about your students?

Are the data only about assessments, or are there other sources of data? If so, what would they be?

What data do you think are most important to provide information about your students?

Are there data that you would like to have but currently are not available to you now? What are they and how much you obtain them?

Are the data you do have sufficient to make decisions about your students' learning

Are your data actionable; that is, do they allow you to figure out what instructional steps are needed for particular students?

Your Background with Data and Beliefs
How long have you been teaching?

Did you receive training on the use of the technologies in the blended learning environment?

Have you received training in how to use data? If so, please describe.

Have you ever taken a course in data-driven decision making?

Can you describe what it means for a teacher to be data literate? What are the skills needed to use data?

Do you consider yourself to be data literate? If not, what do you need to come data literate?

Would your school provide you with learning opportunities for continuing education, graduate education, professional development?

Do you think that using data helps you to improve your classroom practices and your ability to structure instruction based on your students' needs?

Does your school make is clear that data are an important tool? Technologies?

How important do you think data are for your teaching practices?

Appendix B
Screenshots from Galileo[6]

[6] Thank you to ATI, Jason Feld, and Nancy Auslander for providing the project with these example graphics.

Test Monitoring
District: ATI Demo District
Year: 2014 - 2015
School: Adamstown Elementary School
Class: Homeroom 3: MUELLER: 01HRM3
Settings | Dashboard | Digital Curriculums | Help | Forum | Tech Support | Site Map | Logout
Expand To View Settings (2014-15 ATI AZ CCP Math 03 Gr. _Pretest-IE)
Avg Percent Scored
100%
50%
0%
Correct Answer
Incorrect Answer
Partial Credit
Ready for Scoring
--- Not Yet Answered
Name
Earned Pts.
ALFORD, Heidi 26 of 46
BLACK, Gilberto 34 of 46
BLACK, Jeffery 37 of 46
BOWEN, Kristopher 40 of 46
DELEON, Abby 30 of 46
ELLIOTT, Stanley ---
GARZA, Amber 35 of 46
GREER, India 37 of 46
LEACH, Zane ---
LEONARD, Javier 28 of 46
PARK, Jarod 37 of 46
RODRIGUEZ, Selena 27 of 46
ROMERO, Roman 36 of 46
AZ-3.MD.A.1 Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram. [From cluster: Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects]

Intervention Alert

District: ATI Demo District
Year: 2014 - 2015
School: Adamstown Elementary School
Class: Homeroom 3: MUELLER: 01HRM3

Settings | Dashboard | Digital Curriculums | Help | Forum | Tech Support | Site Ma

◉ Mastery Categories ○ Points Earned

Click to return to previous page

✔ *Student took test.*
— *Student did not take test.*
ES *Exceeds Standard. (85.00 %)*
MS *Meets Standard. (65.00 %)*
AS *Approaches Standard. (45.00 %)*
FS *Falls Below Standard. (0.00 %)*

Demonstrated Mastery Of Learning Standards

2014-15 ATI AZ CCP Math 03 Gr. _Pretest-IE	Question count	ALFORD, Heidi	BLACK, Gilberto	BLACK, Jeffery	BOWEN, Kristopher	DELEON, Abby	ELLIOTT, Stanley	GARZA, Amber	GREER, India	LEACH, Zane	LEONARD, Javier	PARK, Jarod	RODRIGUEZ, Selena	ROMERO, Roman	RUSH, Julianna	SCHMIDT, Cameron	SHORT, Patrick	SULLIVAN, Braden	SWANSON, Raven	TUCKER, Vivian	VAUGHAN, Cameron	WALTER, Martin	WEISS, Sharon	Homeroom 3: MUELLER: 01HRM3	Adamstown Elementary School	ATI Demo District	Number of Students Meeting Standard	% of Students Meeting Standard
		✔	✔	✔	✔	✔	—	✔	✔	—	✔	✔	✔	✔	✔	✔	✔	✔	✔	—	✔	✔	✔	✔	✔	✔		
AZ-3.OA.A.1 Interpret products of whole numbers, e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each. For example, describe a context in which a total number of objects can be expressed as 5 × 7. [From cluster: Represent and solve problems involving multiplication and division]	2	ES	ES	ES	ES	ES	---	AS	ES	---	ES	ES	ES	ES	ES	ES	ES	AS	ES	---	ES	AS	AS	78.95%	81.03%	73.40%	15	78.95%
AZ-3.OA.A.2 Interpret whole-number quotients of whole numbers, e.g., interpret 56 ÷ 8 as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into equal shares of 8 objects each. For example, describe a context in which a number of shares or a number of …	1	ES	ES	ES	ES	ES	---	FS	ES	---	ES	ES	FS	ES	FS	ES	ES	ES	ES	---	ES	ES	FS	78.95%	77.59%	67.02%	15	78.95%
… or the same denominator by reasoning about their size. Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g., by using a visual fraction model. [From cluster: Develop understanding of fractions as numbers]	1	ES	ES	ES	FS	FS	---	ES	ES	---	ES	ES	FS	ES	ES	ES	ES	ES	ES	---	FS	ES	ES	78.95%	82.76%	79.43%	15	78.95%
☑ AZ-3.MD.A.1 Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram. [From cluster: Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects]	3	FS	ES	ES	ES	ES	---	ES	ES	---	FS	MS	ES	ES	FS	MS	ES	FS	ES	---	FS	FS	FS	63.16%	75.86%	58.16%	12	63.16%
AZ-3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).1 Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. Excludes multiplicative comparison problems (problems involving notions of "times as much"; see Table 2). [From cluster: Solve problems involving …	2	AS	ES	ES	ES	AS	---	AS	AS	---	ES	ES	AS	ES	AS	ES	ES	FS	AS	---	AS	AS	ES	47.37%	58.62%	47.16%	9	47.37%
… For example, partition a shape into 4 parts with equal area, and describe the area of each part as 1/4 of the area of the shape. [From cluster: Reason with shapes and their attributes]	2	FS	ES	ES	ES	ES	---	ES	ES	---	AS	ES	AS	ES	ES	ES	ES	FS	ES	---	FS	FS	FS	63.16%	58.62%	53.90%	12	63.16%
# of Standards Met		11	14	18	20	14	---	18	20	---	14	20	10	17	19	20	22	12	13	---	4	9	12	---	---	---		
% of Standards Met		42.31%	53.85%	69.23%	76.92%	53.85%	---	69.23%	76.92%	---	53.85%	76.92%	38.46%	65.38%	73.08%	76.92%	84.62%	46.15%	50.00%	---	15.38%	34.62%	46.15%	---	---	---		

Quiz Builder... | Assignments... | print CSV (Excel-compatible format)

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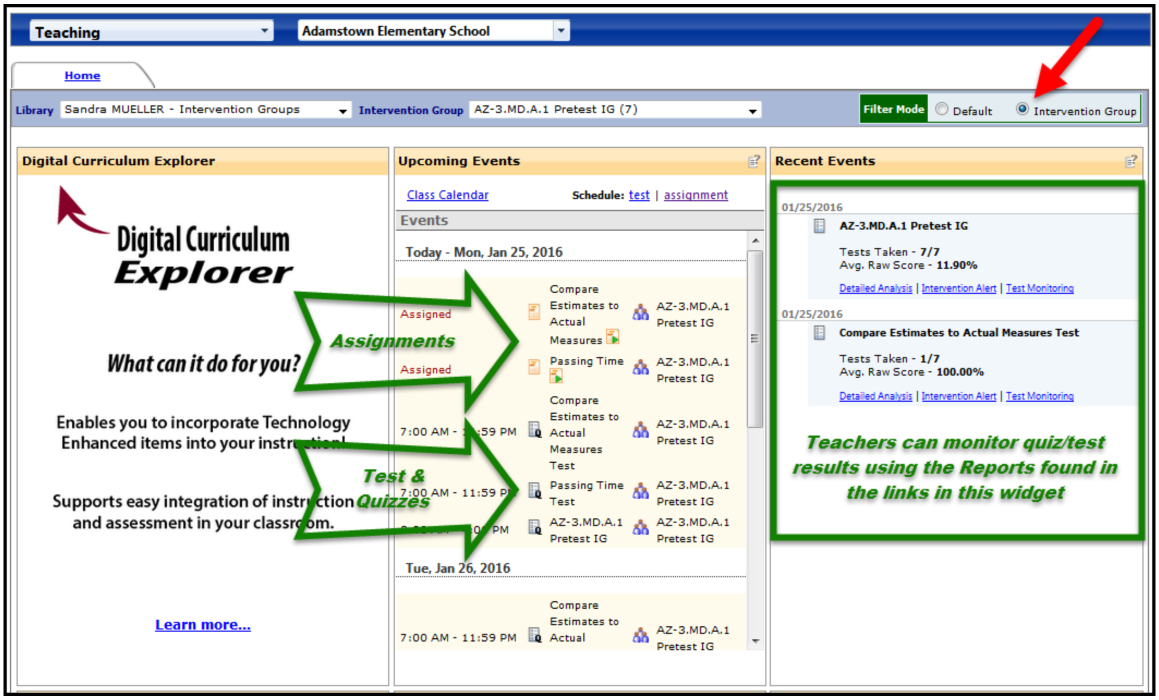
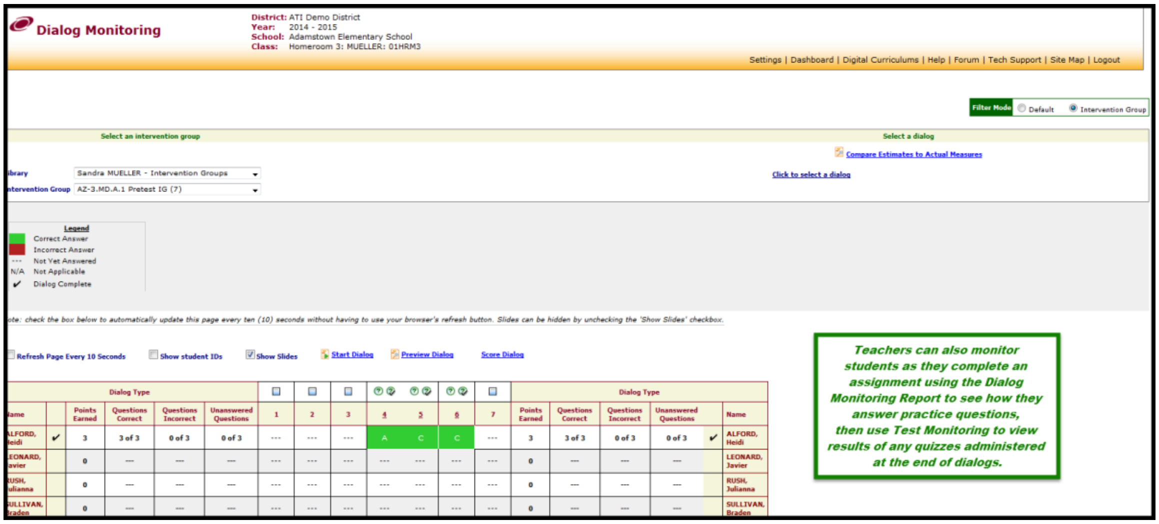
Protected by U.S. Patents 6,322,366; 6,468,085B1; 7,065,516 and others pending.


Teaching
Adamstown Elementary School
Home
Library Sandra MUELLER - Intervention Groups
Intervention Group AZ-3.MD.A.1 Pretest IG (7)
Filter Mode Default Intervention Group
Digital Curriculum Explorer
Digital Curriculum Explorer
What can it do for you?
Enables you to incorporate Technology Enhanced items into your instruction!
Supports easy integration of instruction and assessment in your classroom.
Learn more...
Upcoming Events
Class Calendar
Schedule: test | assignment
Events
Today - Mon, Jan 25, 2016
Assignments
Test & Quizzes
Tue, Jan 26, 2016
Recent Events
01/25/2016
AZ-3.MD.A.1 Pretest IG
Tests Taken - 7/7
Avg. Raw Score - 11.90%
Detailed Analysis | Intervention Alert | Test Monitoring
01/25/2016
Compare Estimates to Actual Measures Test
Tests Taken - 1/7
Avg. Raw Score - 100.00%
Detailed Analysis | Intervention Alert | Test Monitoring
Teachers can monitor quiz/test results using the Reports found in the links in this widget


Dialog Monitoring
District: ATI Demo District
Year: 2014 - 2015
School: Adamstown Elementary School
Class: Homeroom 3: MUELLER: 01HRM3
Settings | Dashboard | Digital Curriculums | Help | Forum | Tech Support | Site Map | Logout
Select an intervention group
Select a dialog
Compare Estimates to Actual Measures
Click to select a dialog
Legend
Correct Answer
Incorrect Answer
Not Yet Answered
Not Applicable
Dialog Complete
Refresh Page Every 10 Seconds
Show student IDs
Show Slides
Start Dialog
Preview Dialog
Score Dialog
Teachers can also monitor students as they complete an assignment using the Dialog Monitoring Report to see how they answer practice questions, then use Test Monitoring to view results of any quizzes administered at the end of dialogs.

Appendix C
Data Literacy Protocol

Skills in the Inquiry Cycle of Data Use			
Identify Problems of Classroom Practice			
I1	Articulate the Problem	22	6
I2	Demonstrate awareness of student privacy (e.g. FERPA, HIPPA, state or local regulations)	6	3
I3	Undertand the contextual issues at the student level	19	7
I4	Undertand the contextual issues at the school level	9	3
I5	Involve stakeholders	11	6
I6	Frame research questions to be studied	14	4
Use Data			
U1	Understand that data should be applied to a specific problem	12	5
U2	Identify possible data sources	12	6
U3	Understand the purposes of different sources of data	11	7
U4	Understand what data are not applicable	10	7
U5	Access, retrieve data	11	4
U6	Use multiple sources of data	16	5
U7	Use quantitative and qualitative data	12	5
U8	Understand elements of data quality -- accuracy, completeness and timeliness	6	5
U9	Can identify inaccurate, misleading or out-of-range data	4	6
U10	Integrate data sources	9	7
U11	Manipulate data	6	6
U12	Examine data	11	4
U13	Prioritize data	4	5
U14	Organize data	6	5
U15	Understand the appropriate level of data (i.e. student-, subgroup-, classroom-, or school-level data as needed)	13	4
U16	Understand basic statistics such as measures of central tendancy and dispersion	5	4
U17	Recognize fair, valid and reliable assessments	8	5
U18	Use both formative and summative assessments	21	6
U19	Incorporate student work as data source	20	7
U20	Recognize (and use) informal classroom information as a source of data	20	7
U21	Use technologies to support data use	19	4
Transform Data Into Information			
TDI1	Diagnose/identify student learning needs	19	6
TDI2	Analyze data	16	5

TDI3	Test assumptions	14	3
TDI4	Generate hypotheses	16	7
TDI5	Predict possible or likely consequences	6	6
TDI6	Use statistics	5	5
TDI7	Understand data displays and representations	9	4
TDI8	Assess patterns and trends	8	6
TDI9	Synthesize diverse data	8	5
TDI10	Summarize data	6	5
TDI11	Communicate, in writing or verbally, at an appropriate level for audience	11	3
TDI12	Interpret – make meaning	13	4
TDI13	Draw inferences and conclusions	15	4
TDI14	Probe for causality	4	1
Transform Information Into a Decision			
TID1	Understand context for decision	15	5
TID2	Determine next steps	19	7
TID3	Individualize instruction	22	6
TID4	Differentiate classroom practice	18	5
TID5	Adjust (slight change in method) classroom practice	20	5
TID6	Plan classroom practice	22	7
TID7	Design classroom practice	22	7
TID8	Implement classroom practice	22	7
TID9	Adapt current classroom practice based on immediate student feedback	21	6
Evaluate Outcomes of a Decision			
E1	Re-analyze a) original problem or b) decision	5	6
E2	Test hypotheses	5	5
E3	Monitor classroom practice shifts	22	7
E4	Monitor for student progress	23	7
E5	Analyze relevant student work for evidence of change in thinking	19	7
E6	Compare data pre- and post-decision	4	4
E7	Determine if any unintended consequences	2	5
E8	Consider need for iterative decision cycle	5	5

Data-Oriented Habits of Mind			
H1	Engaging Students with their personal results	20	7
H2	Ethical use of data	3	7
H3	Belief in data use	4	5
H4	Think critically	7	3
H5	Collaborate (vertically and horizontally)	9	1
H6	Communication Skills with multiple audiences	12	6
H7	Engage in a Continuous Inquiry Cycle	12	6
COMPONENTS OF DLFT / Data Inquiry Cycle			
C1-I	**Identify Problems of Classroom Practice**		
C2-U	**Use Data**		
C3-TDI	**Transform Data Into Information**		
C4-TID	**Transform Information Into a Decision**		
C5-E	**Evaluate Outcomes**		
C6-H	**Habits of Mind**		

Appendix D
Teacher Survey

2015 Teacher Data Use Survey

Contact Information		
Please verify the following information:		
***First Name:**		
***Last Name:**		
***Email Address:**		
All fields with an asterisk (*) are required.		

*1. What subject area(s) are you teaching (or supervising) this year (2014-2015)? (*Required)

Select all that apply.

☐	English/language arts/reading/writing
☐	Mathematics
☐	Science
☐	Social Studies
☐	Foreign language(s)
☐	Visual or performing arts (art, music, etc.)
☐	Physical education/health education
☐	Career/technical education
☐	Other subject area(s):

*2. Please indicate the grade levels of the students you teach. (*Required)

Select all that apply.

☐	Kindergarten
☐	1st
☐	2nd
☐	3rd
☐	4th
☐	5th
☐	6th
☐	7th
☐	8th
☐	9th
☐	10th
☐	11th
☐	12th
☐	Our school doesn't use grade levels

*3. Including this school year (2014-2015), how many total years have you been teaching, regardless of location? (*Required)

[ ] years

*4. Do you hold a regular or standard certificate to teach in this state? (*Required)

Select all that apply.

☐	Yes
☐	No, but I am currently enrolled in a certification program.
☐	No, and I am not currently enrolled in a certification program.

*5. Through which of the following types of programs did you enter teaching? (*Required)

Select all that apply.

☐	Through an undergraduate teacher preparation program.
☐	Through a graduate teacher preparation program.
☐	Through an alternative teacher preparation program (for example, Teach For America, or a program aimed at mid-career changers).
☐	Courses taken after attainment of undergraduate/bachelor's degree, but not as part of a formalized graduate or alternative teacher preparation program (for example, non-degree oriented courses needed for certification taken at a local or online university.
☐	No formal preparation program.
☐	Other, please describe: [ ]

*6. Rate your level of agreement with each of the following statements about your school. (*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
*Teachers at my school collaborate with one another.	○	○	○	○
*Teachers at my school are highly focused on the mission of improving student learning.	○	○	○	○
*Administrators at my school are highly supportive of teachers.	○	○	○	○
*Administrators at my school are highly focused on student learning.	○	○	○	○
*Administrators at my school trust teachers to make decisions about their own instruction.	○	○	○	○

*7. Please indicate whether the following conditions exist in your school and the degree to which each is an obstacle to your efforts to promote student learning using technology such as computers, smartphones, or tablets. If the condition does not exist in your school, please mark "Not applicable." (*Required)

Select one per row.

	Not applicable; condition does not exist in my school	*Condition exists but is not an obstacle*	*Condition exists and is a minor obstacle*	*Condition is a major obstacle*
*Inadequate technology skills among students.	○	○	○	○
*My own limited technology skills.	○	○	○	○
*Lack of support from technology specialists or other staff who can provide technical support.	○	○	○	○
*An inadequate number of computers or devices to accommodate all students.	○	○	○	○
*Slow internet connection or inadequate bandwidth.	○	○	○	○
*Inadequate opportunities to participate in professional development related to technology use.	○	○	○	○
*Problems with hardware, such as insufficient computing power or lack of compatibility with software.	○	○	○	○

*8. Please indicate the extent to which each of the following conditions is an obstacle to your efforts to promote personalized learning for students. If the condition does not exist in your school, please mark "Not applicable." (*Required)

Select one per row.

	Not applicable; condition does not exist in my school	*Condition exists but is not an obstacle*	*Condition exists and is a minor obstacle*	*Condition exists and is a major obstacle*
*Lack of support from school administration.	○	○	○	○
*My own limited knowledge of how to effectively personalize instruction.	○	○	○	○
*Too many students for whom I am responsible.	○	○	○	○
*Too much diversity in achievement levels among my students.	○	○	○	○
*Pressure to cover specific material as a result of state or district standards or testing requirements.	○	○	○	○
*Excessive amounts of time I need to spend developing personalized content.	○	○	○	○
*Inadequate data to help me personalize students' instruction.	○	○	○	○
*An inadequate amount of time to prepare personalized lessons for all students.	○	○	○	○
*High levels of student absenteeism.	○	○	○	○
*High levels of student disciplinary problems.	○	○	○	○

*9. In general, how frequently do you receive the following types of information about the performance of your students? (*Required)

Select one per row.

	Never	*Once a year*	*A few times per year*	*Approximately monthly*	*A few times per month*	*Approximately weekly*	*A few times per week*	*At least daily*
*Scores on assessments in mathematics or language arts	○	○	○	○	○	○	○	○
*Scores on assessments in subjects other than mathematics or language arts	○	○	○	○	○	○	○	○
*Information about student performance on specific concepts or skills	○	○	○	○	○	○	○	○
*Identification of specific students who need extra assistance	○	○	○	○	○	○	○	○
*Identification of specific students who have achieved mastery	○	○	○	○	○	○	○	○
*Non-achievement outcomes (for example, student behavior, attitudes, or motivation)	○	○	○	○	○	○	○	○

*10. This year, to what extent have you used student achievement/mastery data for each of the following purposes? (Consider data provided by instructional software, interim assessments or quizzes, unit or end of course tests, state accountability tests, district benchmark/interim tests, & other tests). (*Required) (*Select one per row.*)

	My school doesn't do this	*Did not use data for this*	*Used data to a small extent*	*Used data to a moderate extent*	*Used data to a large extent*
*Tailoring the pace of instruction to individual students' needs.	○	○	○	○	○
*Tailoring the content of instruction to individual students' needs.	○	○	○	○	○
*Developing recommendations for tutoring or other educational support services for particular students.	○	○	○	○	○
*Identifying topics requiring more or less emphasis in instruction.	○	○	○	○	○
*Reflecting on and discussing teaching and learning with other teachers.	○	○	○	○	○
*Reflection on and discussing learning with my students.	○	○	○	○	○

*11. This year, have you used data on non-achievement outcomes (for example, student behavior, attitudes, or motivation)? (*Required)

Select all that apply.

☐	Yes
☐	No

*12. This year, to what extent have you used data on non-achievement outcomes (for example, student behavior, attitudes, or motivation) for each of the following purposes? (*Required)

Select one per row.

	My school doesn't do this	*Did not use data for this at all*	*Used data to a small extent*	*Used data to a moderate extent*	*Used data to a large extent*
*Tailoring the pace of instruction to individual students' needs.	○	○	○	○	○
*Tailoring the content of instruction to individual students' needs.	○	○	○	○	○
*Developing recommendations for tutoring or other support services for particular students.	○	○	○	○	○
*Reflecting on and discussing learning with my students.	○	○	○	○	○

*13. Please indicate your level of agreement with each of the following statements(*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*	*Not Applicable*
*I have access to high-quality assessment data that help me adapt the pace or content of instruction to meet students' needs.	○	○	○	○	○
*The data system provides real-time data that is actionable.	○	○	○	○	○
*Our school's data system provides information at a level of detail that helps me inform my instruction (e.g. breakdowns for specific skills or topics).	○	○	○	○	○
*I have plenty of data but need help in figuring out how to translate the data int instructional steps.	○	○	○	○	○
*It is easy to create custom assessments that evaluate what students are learning.	○	○	○	○	○
*Our school's data system is easy to use.	○	○	○	○	○
*I can use the school's data system to easily produce the views or reports I need.	○	○	○	○	○
*The technology provides data that are not typically available without that technology.	○	○	○	○	○
*I have the necessary skills and experience to use data to guide my instruction.	○	○	○	○	○

*14. On average throughout the school year, how many hours of instructional time do students experience per week in the class(es) you teach? (*Required)

________________ hours

*15. Teachers use all kinds of information (i.e. data) to help plan for instruction that meets student learning needs. How frequently do you use the following forms of data? (*Required)

Select one per row.

	Less than once a month	*Once or twice a month*	*Weekly or almost weekly*	*A few times a week*
*State Data	○	○	○	○
*Periodic Data	○	○	○	○
*Local Data	○	○	○	○
*Personal Data	○	○	○	○
Other	○	○	○	○

15.1 If you marked the "Other" option above, please specify the form of data here:

*16. How useful are the following forms of data to your practice? (*Required)

Select one per row.

	Not useful	*Somewhat useful*	*Useful*	*Very useful*
*State Data	○	○	○	○
*Periodic Data	○	○	○	○
*Local Data	○	○	○	○
*Personal Data	○	○	○	○
Other	○	○	○	○

16.1 If you marked the "Other" option above, please specify the form of data here:

17. These questions ask about state data. In a typical school year, how often do you do the following? (If you indicated that state data is not available to you, please skip this question.)

Select one per row.

	One or two times a year	*A few times a year*	*Monthly*	*Weekly*
Use state data to identify instructional content to use in class.	○	○	○	○
Use state data to tailor instruction to individual students' needs.	○	○	○	○
Use state data to develop recommendations for additional instructional support.	○	○	○	○
Use state data to form small groups of students for targeted instruction.	○	○	○	○
Discuss state data with a parent or guardian.	○	○	○	○
Discuss state data with a student.	○	○	○	○
Meet with a specialist (e.g., instructional coach or data coach) about state data.	○	○	○	○
Meet with another teacher about state data.	○	○	○	○

18. These questions ask about Local Data developed and used in your school or district. In a typical month, how often do you do the following? (If you indicated that Local Data is not available to you, please go to the next question.)

Select one per row.

	Less than once a month	*Once or twice a month*	*Weekly or almost weekly*	*A few times a week*
Use local data to identify instructional content to use in class.	○	○	○	○
Use local data to tailor instruction to individual students' needs.	○	○	○	○
Use local data to develop recommendations for additional instructional support.	○	○	○	○
Use local data to form small groups of students for targeted instruction.	○	○	○	○
Discuss local data with a parent or guardian.	○	○	○	○
Discuss local data with a student.	○	○	○	○
Meet with a specialist (e.g., instructional coach or data coach) about local data.	○	○	○	○
Meet with another teacher about local data.	○	○	○	○

*19. These questions ask about supports for using data. For "data," please consider only state achievement tests and locally developed assessments. Please indicate how much you agree or disagree with the following statements. (*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
*I am adequately supported in the effective use of data.	○	○	○	○
*I am adequately prepared to use data.	○	○	○	○
*There is someone who answers my questions about using data.	○	○	○	○
*There is someone who helps me change my practice (e.g., my teaching) based on data.	○	○	○	○
*My district provides enough professional development about data use.	○	○	○	○
*My district's professional development is useful for learning about data use.	○	○	○	○

*20. These questions ask how your principal and assistant principal(s) support you in using data. They won't see your responses. For "data," please consider only state achievement tests and locally developed assessments. Please indicate how much you agree or disagree with the following statements. (*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
*My principal or assistant principal(s) encourages data use as a tool to support effective teaching.	○	○	○	○
*My principal or assistant principal(s) creates many opportunities for teachers to use data.	○	○	○	○
*My principal or assistant principal(s) has made sure teachers have plenty of training for data use.	○	○	○	○
*My principal or assistant principal(s) is a good example of an effective data user.	○	○	○	○
*My principal or assistant principal(s) discusses data with me.	○	○	○	○
*My principal or assistant principal(s) creates protected time for using data.	○	○	○	○

*21. Your school or district gives you programs, systems, and other technology to help you access and use student data. The following questions ask about these computer systems. Please indicate how much you agree with the following statements. (*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
*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 at once (e.g., attendance, achievement, demographics).	○	○	○	○
*The computer systems in my district generate displays (e.g., reports, graphs, tables) that are useful to me.	○	○	○	○

*22. These questions ask about your attitudes toward your own use of data. Please consider only state achievement tests and locally developed assessments. Please indicate how much you agree or disagree with the following statements. (*Required)

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
*I am good at using data to diagnose student learning needs.	○	○	○	○
*I am good at adjusting instruction based on data.	○	○	○	○
*I am good at using data to plan lessons.	○	○	○	○
*I am good at using data to set student learning goals.	○	○	○	○

23. As you think about your collaborative team(s), please indicate how much you agree or disagree with the following statements. If you do not have scheduled meetings to work in collaborative teams, please go to the next question.

Select one per row.

	Strongly Disagree	*Disagree*	*Agree*	*Strongly Agree*
Members of my team trust each other.	○	○	○	○
It's ok to discuss feelings and worries with other members of my team.	○	○	○	○
Members of my team respect those colleagues who are experts in their craft.	○	○	○	○
My principal or assistant principal(s) fosters a trusting environment for discussing data in teams.	○	○	○	○

24. What else would you like to share with us about data use?

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San Francisco, California 94107-1242