Technology-Supported Involvement of Entire Faculties in Examination of Student Data for Instructional Improvement

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Student data are gaining increased attention in education, spurred by accountability policies such as those contained in the federal No Child Left Behind legislation. Student data are useful for informing classroom practice, and user-friendly technologies for organizing and accessing data are enabling access by all teachers. In this study, we examine the efforts of three schools to involve entire faculties in the examination of student data, supported by efficient data systems. Results indicate the importance of administrative supports in fostering such use. Data use often resulted in improved teaching practice such as collaboration, better knowledge of student needs, and efficiency of effort. These results are discussed in light of previous research.

Introduction

Student data (e.g., assessment scores, student histories, and demographic information) are an untapped resource in helping educators diagnose student learning needs. Accountability policies such as those contained in the federal No Child Left Behind legislation (NCLB) have brought needed attention to the use of student data. These policies carry the implicit assumption that the availability of data will inform and initiate improvements in educational practice, but mechanisms for bringing data to the classroom level are lacking in these policies. Teachers are a potentially important group to target because of the access teachers have to students and their performance.

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While teachers are often critical of accountability data, preliminary evidence suggests that they will embrace a data initiative when it is soundly implemented and responds to the learning needs of their students (Chen et al. 2005; Lachat and Smith 2005; Massell 2001). However, the notion of involving teachers in data use is easier said than done. Many schools have found the analysis of data to entail a great deal of labor because data are often stored in ways that frustrate flexible analyses (Stringfield et al. 2001).

In response to this problem, new computer technologies have been developed that offer unprecedented, efficient access along with user-friendly interfaces that support all types of users (Wayman et al. 2004). These technologies are necessary to create a sustainable school data initiative, but they are not sufficient. Few educators are prepared to make efficient use of this abundance of data, so these systems must be supplemented with professional support that helps educators turn student data into information that can inform classroom practice. Confounding the situation is the fact that accountability pressures are causing many districts to move quickly in implementing these systems without providing adequate professional development for principal and teacher skill building.

Given this situation, it is important that research provides information about best practices in the use of these systems. We define best practice as data use processes that engage teachers and principals in reflective inquiry for improved practice and achievement. It has been suggested that these systems are of maximum use when entire faculties are actively involved (Wayman et al. 2004). In the present study we provide research on three schools aiming to involve entire faculties in the use of student data systems for instructional improvement.

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Research on School Data Use

The concept of data use to inform school practice may seem new, but this concept has received varied attention in school research literature for 35 years. Many studies of positive outlier, "effective" schools demonstrating unusual academic gains have shown that the thoughtful use of student data positively correlates with a range of measures of student achievement (e.g., Edmonds 1979; Stringfield 1994; Teddlie and Reynolds 2000; Weber 1971). Research on school improvement and school effectiveness has suggested that data use is central to the school improvement process (Chrispeels 1992; Earl and Katz 2002), and there are an increasing number of recently available case studies describing ways in which data have supported educational decisions (e.g., Supovitz and Kline 2003; Symonds 2003; Wayman et al., forthcoming).

Inquiry into student data has been shown to be useful in improving overall school practice. Chrispeels and colleagues (2000) demonstrated that data use can be a strong predictor of the efficacy of school improvement teams: data use not only directly increased the efficacy of these teams but served as a mediator for the positive effect of other factors. Lachat and Smith (2005) found data to be a useful and convenient vehicle for promoting faculty interaction with in-school coaches. Streifer and Schumann (2005) reported precise predictions of student achievement using complex data mining models. Chrispeels and colleagues (2000) noted the reciprocal nature of data use—the more their team learned about and used data, the more the data informed important decisions.

Case studies and interviews suggest that data use may have a positive effect on the people involved in the educational process. Formal and informal research has suggested that schools engaged in extensive data use often evolve toward more professional, collaborative cultures (Chen et al. 2005; Feldman and Tung 2001; Symonds 2003; Young 2006, in this issue). Earl and Katz (2002) noted that school leaders involved in data use often consider themselves in charge of their own destiny, increasingly able to find and use information to inform their school's improvement. Data use can be helpful in changing educator views and attitudes toward educational practice and students: administrators in Massell's (2001) study viewed data use as stimulating a search for new ideas, with data opportunities encouraging many to seek more professional development. Massell (2001) also found that increased communication and knowledge provided by data appeared to be positively altering educator attitudes toward the capabilities for schoolwork of some underperforming groups. Armstrong and Anthes (2001) found that the introduction of data use resulted in heightened teacher expectations for at-risk students, noting

positive changes in teacher attitudes regarding the potential success of previously low-performing students.

While accountability policies do not stress teacher involvement in data-based decision making, it is rational to hypothesize that teacher involvement will be a key element of a fully successful data initiative. Preliminary evidence suggests that, while teachers are often critical of accountability initiatives, they will embrace such policy when it is soundly implemented and responds to the learning needs of their students. Ingram and colleagues (2004) and Massell (2001) showed that while teachers expressed concerns about the appropriateness of and importance assigned to assessments, they also recognized the new information afforded by assessments, along with the stimulus for new ideas brought about by inquiry. Research has shown a variety of ways that teachers can realize improvement through involvement in a data initiative (Chen et al. 2005; Lachat and Smith 2005; Murnane et al. 2005). Further, it has been suggested that the most effective application of data use is to involve all teachers on a faculty (Wayman 2005; Wayman et al. 2004).

Teacher use of data has historically been hampered by access issues. Education historically has produced a plethora of data, but these data have typically been stored in ways rendering them inaccessible to most practitioners. Even successful data use initiatives conducted without technology have been shown to entail an undue amount of effort (Kerr et al. 2006, in this issue; Stringfield et al. 2001; Supovitz and Klein 2003). Recently, this situation has changed with the advent of computer systems with user-friendly interfaces that allow rapid, easy access to student data for teachers and other educational professionals (Wayman et al. 2004). Consequently, the current emphasis on data use requires that schools integrate data delivery technology in order to make best use of data for educational improvement, particularly when teachers are involved (Lachat and Smith 2005; Supovitz and Klein 2003; Wayman et al. 2004).

Computer Systems for Accessing Student Data

An increasing number of computer systems are being marketed for the purpose of efficiently delivering student data to educators, and these systems provide many different functions. Unfortunately, no system supplies comprehensive access to solutions to educational problems, so districts must choose between many types of data systems. Wayman (2005) loosely categorized data systems into three types: (1) student information systems (SIS) that provide real-time accounting of daily school functions (e.g., attendance, schedules) but are typically not designed to provide analysis or access to data beyond the current school year, (2) assessment systems that rapidly organize and analyze frequent

benchmark assessments but are typically not designed to provide access to such data over time, and (3) data warehousing systems that provide access to historical data of all types but are typically not designed for immediate turnaround of new data. Data warehouses and assessment systems are the ones most commonly used for ongoing analysis of student achievement data.

In education, the term "data warehouse" is often used to refer to the collection and organization of all data into one electronic repository. Data warehousing integrates data that are often stored in disconnected areas (e.g., student attendance, discipline, and achievement test data), thus allowing the examination of relationships across a variety of domains. It is common for a SIS and an assessment system to "feed in" to a data warehouse. While the data warehousing concept may sound simple, organizing large, disparate databases into one common store is a complex task. Recent technological gains have resulted in tools and models that efficiently warehouse data for the examination of relationships commonly explored in the education arena.

Schools using assessment systems typically administer periodic student academic assessments throughout the year, often in preparation for high-stakes tests. These assessments may be provided by a vendor or constructed by school personnel. Assessments may be administered by computer or with paper-and-pencil measures, then scanned or entered by hand into the assessment systems. Assessment systems are designed to provide rapid feedback of these assessments but typically allow neither great flexibility of analysis nor long-term storage.

In both types of systems, data are accessed by teachers through user-friendly data presentation interfaces that typically offer the user two types of data access: preformatted reports or query tools. Preformatted reports are previously compiled summaries of data that are available for viewing or printing with one click and require no specifications, alterations, or input from the user. Query tools allow ad hoc data specification, permitting the user to browse data or construct customized reports. Query tools are more common and more powerful in data warehouse software.

Besides unprecedented data access, the promise held by these systems is the ease of use that facilitates examination of student histories and learning tendencies. The data presentation interfaces offered by most commercial vendors are easy to learn and use, employing familiar Web-form elements such as check boxes and pull-down menus. Through these user-friendly systems, data are accessible to all educators of all levels of technical expertise: Most users who can check the weather online or shop on the Internet can quickly learn how to access student data using these interfaces.

Several authors (Mandinach et al. 2005; Mieles and Foley 2005; Wayman 2005; Wayman et al. 2004) have suggested that a data initiative involving teachers would be most useful if teacher involvement was widespread throughout the faculty and supported by efficient data systems. Unfortunately, the

research base is lacking in the study of these practices. Wayman (2005) outlined conditions that would promote full faculty use of data systems, and there are studies of teacher data use with these systems but not under an expectation of full faculty involvement (Chen et al. 2005; Lachat and Smith 2005). An initial step toward establishing a knowledge base in this area would be to draw on the few schools attempting such an initiative.

The Present Study

The overarching goal of the present study is to provide information that could further faculty-wide involvement in the use of student data systems to improve practice. To meet this objective, we visited three schools that were cited as successfully involving their entire faculties in data use, supported by an efficient student data system. We explored two research questions: (1) What facilitates widespread faculty use of these software tools to examine and learn from student data? (2) What changes in faculty practice and attitudes have resulted from the use of these software tools to examine and learn from student data?

Method

Participating Schools

We asked a number of commercial vendors to recommend schools that were not just using their data systems to examine student progress and inform instruction but aiming to involve all teachers. Because of the importance of historical student data (Wayman et al. 2004), we contacted vendors who partnered with districts in offering access to a data warehouse, knowing that data-savvy schools would likely also be employing an assessment system. Three schools whose districts had implemented a data warehouse were recruited for this study. These schools offered a diversity of district and school data initiatives to study, with different forms of implementation.

School A was an elementary school (prekindergarten through fifth grade) from a small district in the northeast United States. This district employed the EDsmart student data system (http://www.edsmartinc.com; for a review, see Wayman et al. [2004]) for data warehousing. EDsmart is a small company that offers data warehousing, analysis, and data mining services for schools. The EDsmart data system is designed mainly for administrator access and requires training to become proficient with the interface. Included in District A's data warehouse were a variety of assessments (e.g., reading, writing, and

cognitive skills) and student demographic data from a SIS (e.g., ethnicity, special education status, and parental information).

District A supported use of EDsmart by principals and other district administrators but had not yet implemented an aggressive initiative to implement faculty use. Principal A accessed the EDsmart system in tandem with a district administrator to explore various educational issues and was involved in collaboration with other district administrators in using data. School A's faculty rarely accessed the EDsmart system, but the results of Principal A's EDsmart inquiries were often passed on to School A faculty and used in a variety of interactions and collaborations.

School A additionally employed the Northwest Evaluation Association's (NWEA; http://www.nwea.org) assessments and data system to provide periodic assessment of reading and other student learning. School A teachers accessed NWEA's data system more than the data warehouse, frequently accessing the NWEA system for data that informed their instruction.

School B was a large school serving grades 5 and 6, located in a small suburban district in the northern United States. This district employed the SchoolNet student data system (http://www.schoolnet.com; for a review, see Wayman et al. [2004]) for data warehousing. SchoolNet is a company that helps schools with instructional management through data delivery and reporting, communication and collaboration, and professional development. The SchoolNet interface is designed for teacher use at any proficiency level. Included in District B's data warehouse were reading and cognitive skills assessments, district-developed assessments, and student demographic data from a SIS (e.g., ethnicity, special education status, and parental information).

District B had recently implemented a long-term, district-wide initiative to involve teachers and administrators in using SchoolNet for instructional improvement. Implementation was to be accomplished incrementally, first involving district schools that were more invested in data use. School B was the most forward of these schools. Faculty from School B all had access to SchoolNet, and many used it consistently.

In addition, School B faculty used Renaissance Learning's (http://www.renlearn.com) computer-adaptive assessments for reading and mathematics, accessing the data through the Renaissance Place software system. District B had not yet loaded these assessments into their data warehouse because of interoperability problems. Principal B was a frequent user of both systems and led individuals and groups in the exploration of data using both systems.

School C was a middle school (grades 6 through 8), located in a large district in the southern United States. As did District B, District C used the SchoolNet student data system for data warehousing and instructional management. District C's data warehouse contained reading and writing assessments, district-

developed assessments, and student demographic data from a SIS (e.g., ethnicity, special education status, and parental information).

District C had recently installed SchoolNet and was in the first year of rapidly implementing an aggressive district-wide data initiative, simultaneously rolling out this initiative with the SchoolNet software. Using a train-the-trainer approach that spanned one school year, District C trained all district teachers and administrators in use of SchoolNet and baseline strategies for data use. During this study, School C was in the first postimplementation year of the data initiative. All faculty from School C were consistent users of SchoolNet for lesson plans, and some were consistent users for student data. Principal C was an avid data user and supporter of the initiative, having implemented varied data projects within School C prior to implementation of the district initiative. School C faculty also used Renaissance Learning's computer-adaptive assessments for reading and mathematics, with the same interoperability problems preventing them from loading these data into the warehouse.

Data Collection and Analysis

Data to inform the present study were collected through focus groups, and interviews were conducted with principals and teachers in the study schools and with district administrators. Discussions were based on a variety of open-ended interview questions about individual and group use of student data to inform instruction and the use of the computer systems.

Interviews in Schools A and B were conducted during one-day site visits in the fall of 2004. Data collection for School C was conducted through a series of telephone interviews with diverse participants. A total of 28 participants were interviewed for the present study, consisting of four district administrators, five principals and assistant principals, and 19 teachers.

At the completion of data collection, recordings of the sessions were transcribed, and transcripts of the sessions were examined for common and contrasting themes regarding best practices in using data and data systems to inform instruction.

Results

Description of data from interviews and focus groups will be outlined in two sections corresponding with the two research questions listed above: (1) factors that facilitate widespread faculty use of data tools to inform practice and (2) changes in faculty practice and attitudes resulting from use of these tools.

Analyses indicated that faculty-wide use of a computer student data system was facilitated by various types of structures, practices, and supports that help educators utilize a system in support of a school or district data initiative. In our interviews and focus groups, five themes emerged as particularly relevant: district support, principal involvement, efficient data access, time afforded to learn the system and examine student data, and nonthreatening triangulation of data (the use of multiple data sources in a positive manner).

District support.—In all three districts, we saw multiple examples of district support providing opportunities for building-level educators to use data systems for educational improvement.

Formal district data plans were found in Districts B and C. District A was supportive of varied school data and technology initiatives (and particularly supportive of Principal A), but the district had not yet implemented an integrated district-wide data initiative. Districts B and C had both crafted district-wide plans for the implementation of their data systems to support and increase already-existing data initiatives. Both districts believed technology was necessary to involve teachers in examining student data, so both implementation plans were crafted toward the practical use of their data systems for school improvement.

District B created a plan with a variety of forms of district-sponsored professional development for data technology use (e.g., individual development, group development, and study groups). These opportunities were aligned with state standards and thus were focused on curriculum and instruction, with data and technology presented as supports for the larger curriculum goal. Teachers could use these opportunities toward state credentialing.

District C provided similar support opportunities and outlined a focused and aggressive plan for simultaneously introducing data system training with their new district-wide data use initiative. The expectation was that all teachers and principals would become involved in the use of the data system to examine student data. Under this plan, 500 educators were certified in the use of the data system. In turn, these educators were responsible for preparing groups of colleagues to use the system. This plan was very specific in terms of time lines, and District C was able to prepare educators district wide within one year.

In all three districts, administrators held strong philosophical positions on the service of technology for education. As evidenced by district initiatives, administrators in Districts B and C believed that there should be a seamless partnership between technology and curriculum, and administrators in District A were considering plans toward this end. As one administrator in District C noted, teachers have traditionally been invested in curriculum work, but using

technology is new to most. Consequently, administrators in all three districts stressed the importance of continually directing attention toward the use of these systems for classroom improvement. A District B administrator said, "if we don't keep putting this in front of teachers, it won't stay a part of their professional lives."

Principal involvement.—Interviewees at all levels were clear that principal leadership was key in promoting widespread faculty use of data systems. The principals of all three schools believed that data should be used to support decisions in their schools, and these expectations were communicated and modeled to their faculties. Teachers in each school explicitly singled out their principals as a major factor in the success of their data initiatives.

All three principals stated that their goal was to lead their faculties to become independent users of student data rather than making teachers dependent on the principals. This is in line with the findings of Stringfield and colleagues (2001), who cautioned that data initiatives often succeed because of an extraordinary amount of time and effort spent by one or more individuals and, thus, are often unsustainable when these individuals leave the school. Leading a data initiative in this manner can be difficult because principals are often reluctant to delegate tasks for fear the tasks would be done incorrectly (Supovitz and Klein 2003). Despite these difficulties, our principals considered the effort worthwhile. Principal B commented, "it's just good leadership." Principals employed many methods such as allowing time for data inquiry, spending time with groups and individuals on effective data techniques, and the use of distributed leadership skills. These methods will be discussed in later sections.

Although most teachers we interviewed expressed support for data use, our principals described some resistance by teachers, borne out of a lack of preparedness for data use and an unfamiliarity with data technology. To address resistance, all three principals made efforts to help build teacher capacity and help teachers see benefits from using data. Principals reported that data systems eased this transition because they were easy to learn and offered value.

To this end, principals worked directly with specific teachers and reported this as successful in building buy-in. Each had also focused their initiatives around specific, measurable goals that provided guidance and gave concrete results from using data. Understanding that lack of preparation was a contributor to resistance, Principal C described the positive effect of working directly with faculty, saying, "You have to teach teachers, and bring them along, help them to see how to think about their instruction in light of this information." Principal B had established a School Improvement Team that worked closely with both the principal and faculty in tying together data analysis with faculty-set school improvement goals.

Principals also reported that some of the initial resistance was alleviated by encouraging teachers to work in groups. Besides providing mutual support,

this afforded opportunities to see others being successful in similar situations. Principal A noted, "You can only rationalize so long that your kids are doing poorly because they started poorly when someone else is doing well with a similar group." Principal A further noted that this sort of pressure is a positive when the data climate is presented in a nonthreatening manner.

Nonthreatening triangulation of data.—An administrator from District B pointed out that "you need lots of data to understand kids." The previous section notes the care these principals took to ensure that teachers felt supported by data. These concomitant points describe a phenomenon that we will call "nonthreatening triangulation" of data, or the use of multiple sources of information about a student in a fashion that is not threatening to teachers.

Principal B pointed out that her leadership goal was "not to punish, but improve and celebrate." To this end, all three principals described concerted efforts to ensure that their teachers saw positives from the data initiative. Often, these efforts surrounded teacher-principal interaction around improved pedagogy. Principal A said, "We're having wonderful conversations with teachers. We're doing a lot of things well, but there are things we could do better. And there are things we thought we were doing well that we should improve." Principals B and C reported positives in using student data reports to support teacher evaluation.

Recognizing that no one data source would describe student learning, the schools and districts in this study had employed multiple sources of data in an effort to gain a whole picture. In addition to state tests, they were using periodic forms of assessment in reading, writing, math, and cognitive skills. Our interviews indicated that working with multiple sources helped teachers view separate sources as pieces to an overall puzzle. A good example of this comes from School A, which had chosen to focus heavily on early literacy. Decisions made about student literacy learning required at least three data points, one of which was the teacher's professional judgment. Principals and teachers in all three schools noted that the data systems made the use of multiple sources possible—each school had used varied sources earlier but reported chronic time inefficiencies alleviated by these systems.

Teacher interviews showed principals' efforts to be successful. Teacher descriptions of their data use were in line with the principal goals described above, and many teachers directly stated that they felt comfortable with data use because of the tone set by the principals. Although no dissenting views were heard regarding a nonthreatening climate, we will later discuss reservations expressed about the quantity of assessments.

Efficient data access.—Each of our study schools had used data for school improvement prior to the implementation of their student data system, but these data were stored in disparate locations and not easily accessible. Personnel at each school noted efficiency advantages provided by the data systems

that they now used. Principal C recalled the effort formerly required to assemble varied forms of student data and described present one-click access to data as a "huge advantage" to teachers. Principal B provided a good summary statement of the advantages offered by efficient access: "We're used to using data, but now we have more meaningful data."

Interviewees commented on many factors regarding efficient data access with their systems, such as user friendliness, system speed and updates, timely data, and longitudinal data. We heard ways that these factors both enabled and hindered efficient data access.

Principals cited user-friendly interfaces as helpful in introducing and furthering data use with these systems, and many teachers commented on the ease with which they were able to access and examine student data. Those who had worked with data prior to technology implementation noted time savings. Many new users were happy that the user-friendly interfaces helped them spend less time learning the software and more time learning data techniques. Data system interfaces were not without detractors. Although most spoke highly of SchoolNet's interface, two teachers in School B commented that they wished their SchoolNet software could be more customizable. Additionally, although District A had a wealth of useful data available in the EDsmart data warehouse, the EDsmart interface is designed for administrative users with ample training. Teachers in School A did not access the data warehouse because of this interface.

Despite teachers being generally satisfied with the interface, interviews revealed some frustration with response speeds. During peak use times, interviewees reported slow response times and occasional crashes. Through interviews with administrators, it was impossible to determine if these issues were due to vendor capacity, district capacity, or some combination. Interviewees also gave mixed reviews to the rapidity with which data were updated in data warehouses: District A administrators find it very useful to load NWEA assessments into their data warehouse for joint analysis with other variables, but district personnel limitations allow only three such uploads per year. Educators in School B were happy with the breadth of data available, but we spoke with one teacher who was doing analyses with assessment data independent of the data warehouse because the data had not been loaded yet. Although School C teachers noted that their district had greatly improved capacity to provide accurate student data because of the data warehouse, they also reported that mobile students' data often were inaccurate and expressed a desire to have Renaissance Learning assessments available in the warehouse.

Rapid feedback is an important support for teachers, and nearly every interviewee noted the importance of getting assessment data results back quickly. There was frequent criticism of state assessments (e.g., "by the time we get them back, we no longer have these students") and great support for

school-administered assessments such as Renaissance Learning and NWEA. Still, teachers in both schools noted how helpful it was to have state data at the start of the school year to learn more about incoming students. The states in which Districts B and C were located were improving their abilities to get data to the schools, and these districts were improving their abilities to load state data into their warehouses.

In using historical student data, our interviewees presented a conflict between what they said and did. Educators voiced frequent criticism of data that were more than a few weeks old: one teacher termed this "dead data," and another said, "I need to know what my students are doing now." Despite these criticisms, teachers in these schools were making frequent use of longitudinal data through examination of student profiles that summarize a student's academic achievement history. The use of longitudinal data was most common in Schools B and C, where teachers were directly accessing a data warehouse. In School A, one staff member used the warehouse to construct student profiles made of longitudinal data and current assessments; many teachers in School A reported that these profiles were useful, and some wished for personal access to such data.

Time to examine data.—Results from these interviews illustrate the importance of giving teachers time during the work week to examine and learn from student data. Teacher comments were typical of a School B teacher: "[Data use] makes our education process more efficient—but you have to have the time to do it."

While noting the difficulty of finding time to give teachers for data use, administrators and principals also voiced the importance of finding ways to do it. Principal C described a system for creatively working the contractual planning time into her data initiative. Principal B was infusing data use into school teaming structures and sometimes used faculty meeting time to explain data methods. Principal A used a variety of meeting structures already present in the school to use data for learning decisions. All three principals used staff development days to help teachers learn methods and examine student data.

Changes in Faculty Practice

Our second research goal was to identify changes in faculty practices and attitudes that resulted from using student data systems. Our interviews uncovered four prevalent types of changes: increased sense of teacher efficiency, better response to student needs, examining practice, and increased collaboration.

Increased sense of teacher efficiency.—In describing changes to their professional lives enabled by this new technology, many respondents cited increased efficiency in varied forms. For instance, many teachers cited an increased sense

of professionalism. One teacher in School B noted that implementation of their data system "raises the school climate to the level of a small corporation. Professional. Efficient. Our education process is more efficient and more mobile." Other teachers cited feelings of pride that their school was participating in a data initiative and that they themselves were able to access this technology. Administrators specifically mentioned observing this attitude change in teachers.

Other efficiencies involved everyday work, where time efficiencies freed teachers to gain more knowledge and apply practice better. A good example was offered by an educator in School C, who described marked improvements in access to special program data. Previously, these data were incomplete and inaccurate, and educators spent much time collecting and organizing it. Now, this educator noted, they were able to access it quickly and accurately, "and we actually have time to talk about what we're doing for the kids." Teachers who accessed student profiles (academic histories) talked about how much information they could quickly access about a student, especially at the beginning of the year. Such information was previously accessible in a student's permanent record, accessible only in the office by one teacher at a time. One teacher in School B showed us a system she had used for years that involved transcribing numbers from state reports to graphs and Excel spreadsheets. The availability of a student data system drastically reduced the work this teacher now had to invest in these same analyses, while increasing her capacity to explore more.

Teachers in Schools B and C spoke of the added efficiency of accessing their data warehouses from home, for everything from planning to parental contact. In fact, frequent mention was made of using nonachievement data such as parental names and phone numbers; while acknowledging that this information was not directly related to achievement, these teachers pointed out that such access allowed them to concentrate more fully on other achievement-related issues. A School C teacher noted that this access allowed him to react to and resolve discipline and other problems faster. He offered an example where he was able to call a parent from home hours after a behavior problem arose and saw a marked improvement the next day in both behavior and learning. He said that without this system, it would have taken longer to resolve the problem, and the student's learning would have suffered.

Our interviews also indicated areas where data systems could provide more efficiency. Teachers in School A found student profiles assembled by their technology person to be very useful, and many wished that they could access profiles themselves. Efficiency was increased by offering these profiles, but since District A's warehouse was not designed for teacher access, administrators and teachers acknowledged that efficiency was dampened by spending resources on constructing these profiles. Teachers in Schools B and C were encountering system problems described earlier, and we observed two teachers

in School B who were conducting analyses on their own because the needed data were not loaded into their warehouse.

Better response to student needs.—Strikingly, the ability to respond better to student learning needs was cited by every participant as a benefit provided by these systems. Repeatedly, educators used the word "whole," describing that the use of student data allowed them a deeper and more rounded view of their students' learning. A teacher in School B said, "When you're able to see patterns for student performance, it gives you a better, more well-rounded understanding of what a student's capable of. We were not able to do that before we had this technology."

Most examples of this response entailed gaining an overall sense of student needs, then refining this information as necessary. School B teachers often started with a student profile for initial diagnosis, then examined specific items on state and local assessments. School C teachers were enthusiastic about a feature of SchoolNet that allowed them to view each other's notes on student learning plans. School A teachers were aggregating and disaggregating recent diagnostic information, and administrators described a pilot plan to provide teachers additional student historical profiles at the start of each year.

Better grouping of students was a common result cited by our teachers. A good example was given by a pair of School B teachers identifying children for their gifted and talented program. Previously combining teacher recommendations with a cognitive assessment, these teachers were now incorporating a variety of current and historical student assessments. In presenting detailed information of contradictions and consistencies for individual students, these teachers stressed that used alone, these data might provide a misdiagnosis. The teachers believed that the new process afforded by the data system was better. They hoped to demonstrate increased student success as more data were gathered on this method.

Reflecting on practice.—Often, the use of complex databases is seen as a sterile, dehumanizing task. In fact, the educators in our study often observed that gaining "whole" knowledge of student learning enabled them to examine their own practice and make changes that provided better learning experiences for students. Responses such as, "as a teacher, I'm planning much better," "[I'm] fine-tuning what my strengths and weaknesses are," and "it gives me a focus" were typical of teachers who used these systems to examine student data. One seasoned data user said, "I can always do more based on this."

Many teachers felt that they were better able to tailor instruction because they had more specific information, as evidenced by a School A teacher's comment, "It appears when students are working in a large group that they're getting it, but when you get them individually, you see different. These frequent assessments are good for identifying this." Almost every teacher had at least one example of how (s)he provided added instructional supports based on

newly accessible data. This often involved enhanced differentiation of instruction. For instance, a pair of teachers in School B described a complex system of team teaching where the two teachers combined classes for certain lessons, then formed subgroups of students to split out for other lessons or small-group help. A group of teachers in School A described a process they use to identify individual students for enrichment or remediation, based on frequent local assessments. In all examples, the teachers reported a data system to be the primary support.

Although data systems provide unprecedented access to a large amount of student data, teachers in all schools expressed some difficulty in connecting these data to instruction, citing lack of preparation. Efforts were under way to improve this. One of Principal B's goals was to help teachers connect instruction and assessment, and Principal B was leading teachers in writing their own assessments to learn and reinforce this connection. School B teachers reported this effort to be successful not only in helping them understand the meaning of data but in identifying specific aspects of their instruction that could be improved. District A personnel reported a similar initiative planned district wide for the following year, and Principal A had begun piloting this process with selected teachers to learn successes and barriers. Other examples were given by all three principals about meeting with individuals or groups of teachers to examine data from the data system and to connect these data to daily practice.

Despite the enthusiasm over increased data access, some teachers were dubious as to whether this access had improved their overall practice. Further questioning revealed these concerns not to be related to the actual work of examining student data—in fact, these teachers were also ones who described instances where data access had helped them improve practice. Instead, these concerns were related to the time taken away from instruction to administer assessments.

We heard brief comments regarding these concerns in Schools B and C and more in School A, where more assessment was being done. Frustrations were expressed by one teacher in School A who said, "Let's add up all the days we spend gathering information, how much time do we actually have to teach?" Besides time, there was a feeling that assessment created a burgeoning curriculum at the expense of other practices. Teachers who expressed this concern were ambivalent, as stated by a School A teacher who said, "I can see my students growing through these scores, but I've dropped some things I know to be good."

Teacher concerns were not lost on administrators in this study. An administrator in District B discussed these concerns, noting the importance of maintaining balance. Principals in all three schools were working with teachers to create more overlap and connection between assessment and instruction; Prin-

cipal C noted that her goal was that her faculty eventually would see these as one entity.

Collaboration.—Our interviewees cited many and varied ways that their professional collaboration had improved as a result of the data access provided by these systems. Teachers in all three schools spoke of having a common language ("now, one person's 80 is another person's 80") and frequently noted that data created more opportunity and need for interaction. Teachers spoke of collaboration that was more academic and professional than before. In all schools, we heard of informal support networks forming to understand data better. Principal A commented that data brought together staff who ordinarily would not have collaborated because of roles or style.

Our interviews revealed many varied examples of such collaboration. Because they had longitudinal data available from their data warehouse, School C had recently changed to a "vertical teaming" structure that teamed teachers from sixth, seventh, and eighth grades within subject. These teams met weekly, and Principal C joined them biweekly, with conversations focused around instruction. School C teachers also reported a marked increase in collaboration resulting from a feature of SchoolNet that allowed them to share notes in a student learning plan. Teachers reported enthusiasm for this method, noting that it created an informal learning plan for every child. Also, this module allowed them to connect to a broader set of techniques—one teacher noted, "before, we had to find each other in the hall, or just not at all. This makes our job a lot easier."

Principal B was requiring analysis and discussion of data to be a part of meetings. In faculty meetings, team meetings, principal-teacher meetings, and parent meetings, teachers were required to bring data summaries that provided insight into a particular problem. Teachers were accustomed to and supportive of this process. Principal B noted overall faculty growth resulting from these collaborations, saying, "Before, they asked, 'what do we do with this data?' Now they ask, 'what does this data mean?'" The one complaint we heard was from a group who felt that they did not have appropriate data to address a particular problem. Principal B saw a positive in this complaint, saying that it indicated a high level of critical thought about the role of data in solving this problem. She also noted that it underscored the ongoing search for appropriate data.

In School A, the principal and teachers cited a strong ethic of collaboration that had been made better by introducing frequent assessment and feedback. For example, two teachers described an instance where a third-grade teacher and a second-grade teacher found the assessment levels of their classes were similar. They devised a plan to create working pairs and groups of students that enabled students to help younger students on selected learning objectives. In another example, they devised a system that formed various groups of

students from the entire third grade based on assessment scores. Every faculty member involved with third grade worked with every group on different topics (e.g., the special education teacher taught the enrichment group one day). Teachers reported this to be helpful to the students and "made us stretch" in a positive manner.

Discussion

We have presented results that describe characteristics of three schools that are successful at involving teachers in using efficient student data technology to examine student data and inform classroom practice. These schools were previously involved in data use, but the results show the implementation of these new systems to have greatly increased school capacity to use data and involve all faculty. The results also indicate that supports provided by the district, and the principal in particular, were helpful in promoting faculty involvement. Teachers believed that aspects of their own practices were improving. They reported using student histories and assessment data to gain a better overall picture of student needs. Many teachers reported believing themselves to be more efficient. They also viewed themselves as implementing better pedagogical techniques such as effective differentiation and learning through collaboration. However, not all was rosy. Teachers cited problems with the data systems and lack of preparation as barriers to data use. Some teachers cited a growing curriculum as a potential barrier to more effective teaching.

Although the results of this study have provided valuable knowledge for educators, researchers, and policy makers interested in the use of data to improve practice, some cautions are in order in interpreting these results. First, these schools were chosen for observation because of their successful data initiatives. Their principals were unusually interested in data use, and their faculties were unusually involved. Because of these characteristics, these schools provided good preliminary evidence toward constructing good practice, but they necessarily are not representative of "typical" schools. Second, we caution against reifying school practice as tomorrow's "best practice." While it is true that there is much to be learned from today's school data practices, many educators in these schools emphasize that they are unprepared to use data fully. This point is evidenced by our inability to gather good information when teachers were asked what they wished for in data software. Most educators answered as a teacher from School B did: "I don't know what I don't know." Consequently, any research on school data practices should be interpreted in light of prior knowledge. In this section we will provide such discussion.

These results prove that it is possible to involve most or all faculty in the

use of student data and suggest that computer data systems are essential to the success of such an initiative. The factors found to be supportive of success, such as district and principal support, seem transferable to other situations. Still, personnel in these schools had become unusually interested in data use, and the degree to which these successes may be scaled to other schools is unknown. What aspects are contextual, and what are consistent across schools? Can the climate of inquiry built by these districts and principals, and previously shown to be important (Copland 2003; Ingram et al. 2004), be created in the school population at large? Other districts may implement data systems, but are the supports for system use described here generalizable? These and other questions should be explored in further research.

According to the participants in this study, technology was a major factor in allowing them to pursue extended analysis of student data and in involving all faculty rather than just an interested few. We heard participants who were previously data users speak of increased value afforded by these systems, and we heard data novices say that the systems allowed them entry into data use. Still, technology use by teachers can be a double-edged sword. In one school, we heard complaints that a difficult user interface inhibited teacher use. Additionally, we heard of the increased work technology can bring, with some teachers believing that an increased ability to process assessment resulted in an increased curriculum load. Many comments we heard from teachers described how technology made their work more efficient. System designers and principals must take care to ensure that the application of data systems helps teachers in their work rather than lengthening their day.

Consistent with other studies (Copland 2003; Feldman and Tung 2001; Lachat and Smith 2005; Young 2006, in this issue), these results place great importance on the role of the principal in a successful data initiative. Other research has cautioned against heavy dependence on one person in leadership for data use (Copland 2003; Stringfield et al. 2001). The principals in our study understood the importance of building capacity and independence among the faculty and were practicing sound distributed leadership techniques for inquiry such as those put forth by Copland (2003). Still, the ultimate test of these initiatives will come when other leaders come to these schools. More generally, it is important to learn whether these practices may be extended to all principals at large.

As with other research (e.g., Kerr et al. 2006, in this issue; Stiggins 2002; Supovitz and Klein 2003), these results show that teachers want nearly instant feedback on student learning. In contrast, however, these results also showed extensive, high-quality uses of student histories, including assessments from prior years. These historical data were used in initial diagnoses but were also used to augment periodic assessment information. The use of historical data is not uncommon (Brunner et al. 2005; Lachat and Smith 2005) but has not

often been shown in an environment rich in rapidly returned assessments, as in these schools. The fact that these teachers still found extensive use of historical data might be explained by better data access and presentation afforded by contemporary data warehouses. For example, teachers in Supovitz and Klein's (2003) study did not find prior years' state test data useful, but the authors also noted that a lack of technology access was a barrier for these teachers. Further research can show if the utility of historic data is isolated to these schools or is an educational asset in diverse, well-supported environments.

Educator collaboration was reported to have increased in these schools. Previously discussed as a possible benefit of data system implementation (Chen et al. 2005; Lachat and Smith 2005; Wayman 2005), collaboration has also been promoted as good practice in conducting inquiry (Massell 2001; Murphy 2002; Young 2006, in this issue). In our study, teachers believed that the joint supports of data systems and principal support enabled varied and effective collaboration in ways previously unrealized. Educators spoke of the improvement and increase of conversations among educators, administrators, and parents that was enabled as a result of technology; these educators noted that data produced by the system was a common and respected conversation starter. One school was enthusiastic about faculty note-sharing around data, enabled by their data system. We also heard examples of educators refining a common language about practice, learning, and measurement as a result of data use. This process, termed "calibration" by Wayman and colleagues (forthcoming), has also been described in varied ways by other researchers (Murphy 2002; Supovitz and Klein 2003; Young 2006, in this issue). It is especially important for data use, given often-conflicting opinions of what constitutes good evidence (Coburn and Talbert 2006, in this issue). Technology appears to have opened new forms of collaboration in these schools, so further research should explore this relationship.

The teachers in our study thought that the data techniques they were employing were helping them improve their practice, and they offered numerous examples. Some cited improvements are commonly seen in data use research, such as collaboration, better differentiation, and exploration of at-risk student needs (Brunner et al. 2005; Chen et al. 2005; Feldman and Tung 2001; Lachat and Smith 2005; Massell 2001). Other cited improvements have not been commonly shown in data use research, such as learning plans for all students and an emphasis on improving gifted and talented education. Many of these improvements were possible because teachers trusted that data were used for school improvement. This is important in light of research that shows teacher suspicion of data (Ingram et al. 2004); principals in this study ensured that data were used for diagnostic purposes that were seen by teachers as beneficial and nonthreatening. We may characterize this by suggesting that

practice was improving because these schools were helping teachers *use* data rather than *be used* by data.

By contrast, there were some teachers who felt efficient assessment led to a burdening curriculum and were hesitant to say that these new practices had made them better teachers overall. Mandinach and colleagues (2005) found a similar phenomenon in data-rich environments, and Ingram and colleagues (2004) documented the reticence shown by teachers to causally link assessment and improved practice. These conflicting results underscore the importance of further research attention to the general issue of assessment and practice—as we learn new and better practices resulting from data use, we must also take care to understand the effects that data initiatives may have on other areas of practice.

Finally, our study was not designed to address the causal relationships among data use, educational practice, and student learning. The teachers in our study felt the improvement in their practice benefited students and led to improved student learning, and administrators cited increased test scores. Still, without a longitudinal experiment, it is impossible to extend beyond these anecdotal associations, nor is it possible to attribute test score increases to this or any other initiative. Future research should be conducted experimentally that demonstrates the effects of data initiatives, such as those undertaken in these districts, on student performance and learning.

Conclusion

There is a growing body of literature about "what works" in using student data for educational improvement. We observed the practice of three schools engaging in exemplary use of student data, and we demonstrated that full faculty involvement in a data initiative supported by an efficient student data system is attainable. Results from this study indicate that these teachers were able to use these systems to go surprisingly deep in examining student learning and their practice. With district support and committed principals, these teachers felt that their practice had improved in ways such as differentiation of instruction and increased professional collaboration.

Results from this study provide new insight into school data use and suggest that it may be possible to attain more from a data initiative than previously thought. Still, the present study is a necessarily limited case study of three schools selected for their previously emerging abilities in using data. Hence, these results, however promising, should be taken as opportunities to pursue further research. It is our hope that this information is helpful to educators, researchers, policy makers, and educators looking to learn and advance this new and exciting aspect of education.

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