

A Systemic View of Improving Data Literacy into Educator Preparation¹

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The scope and nature of data available to educators is growing at an increasing rate. Parallel to this growth in data is the awareness that all educators must understand how to use tangible evidence to inform their decisions, rather than use anecdotes, intuitions, or personal preferences. Helping educators to become data literate is not as simple as it may seem. Training the existing cohort of educators currently out in schools is an expensive and daunting enterprise. Preparing pre-service candidates may be even more complicated as multiple stakeholders seek to influence that preparation. This article takes a systemic perspective to examine what schools of education, professional credentialing organizations, state departments of education and their licensing agencies, and professional development providers can do to prepare and train the nation's educators to use data effectively to make instructional, administrative, policy, and other decisions. The article first provides some context and trends around data literacy, including supportive technologies, standards, and accreditation. It then describes knowledge around the development of data literacy, including an exploration of requisite skills and knowledge, current practices in schools of education, and the roles of various stakeholder groups. The article then explores the systemic nature of the components that can

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contribute to the development of data literacy, noting gaps in research and postulating a framework to move the field forward.

What is Data Literacy?

The field is now working on a common definition of data literacy (Mandinach & Gummer, 2012a). In this paper, we broadly define data literacy as the ability to understand and use data effectively to inform decisions. It is comprised of a specific skill set and knowledge base that enables educators to transform data into information and ultimately to actionable knowledge (Mandinach, Honey, Light, & Brunner, 2008). These skills include knowing how to identify collect, organize, analyze, summarize, and prioritize data. They also include how to develop hypotheses, identify problems, interpret the data, and determine, plan, implement, and monitor courses of action. The decisions that educators need to use data to inform are multiple and diverse, and data literacy is tailored to the specific use. For instance, teachers need to combine data literacy with pedagogical content knowledge (Shulman, 1986) to affect instructional practice. Mandinach (2009, 2012) has termed this pedagogical data literacy, while Means, Chen, DeBarger, and Padilla (2011) refer to it as instructional decision making.

The Emerging Importance of Data Literacy

The pressures and incentives that are driving the need for data literacy have come from multiple directions. Four trends also have emerged: (a) the increased emphasis on data in federal policy; (b) the development of the statewide longitudinal data systems (SLDSs); (c) the growth of local data systems; and (d) additions to standards and accreditation processes that address data literacy. Furthermore, the push to use data is not

unique to education. Education can learn from the trends seen in medicine and business where data-driven practices have been embedded for many years.

Federal Policy Issues

Arne Duncan, the Secretary of Education, has extensively addressed the importance of educators using data to inform their practice (2009a, 2009b, 2009c, 2010a, 2010b). Duncan (2009b) sees data use as an emerging priority at all levels of the education system. “I am a believer in the power of data to drive our decisions. Data gives us the roadmap to reform. It tells us where we are, where we need to go, and who is most at risk.” Duncan continues, “Our best teachers today are using real time data in ways that would have been unimaginable just five years ago. They need to know how well their students are performing. They want to know exactly what they need to do to teach and how to teach it.” Further, John Easton, the Director of the Institute of Education Sciences (IES), has remarked that he sees the use of data as the means by which improvement of student learning and schools will occur (2009, 2010). The clear message is that data-driven decision making is a fundamental process that will bring about continuous improvement within the education system.

Statewide Longitudinal Data Systems

IES has focused on the development of state-level technological infrastructure through the SLDS Grant Program, which was created for the purpose of developing state technology solutions. The implicit message is to build the technology first and then focus on building the human capacity to use the systems and the data. Since its inception in 2002, the SLDS Program has provided \$514 million in funding, not including a forthcoming round of funding that will be awarded in 2012. It also included funding

through the American Recovery and Reinvestment Act (ARRA, 2009) because data systems are one of its four pillars. The SLDS Program:

is designed to aid state education agencies in developing and implementing longitudinal data systems. These systems are intended to enhance the ability of States to efficiently and accurately manage, analyze, and use education data, including individual student records. The data systems developed with funds from these grants should help States, districts, schools, and teachers make data-driven decisions to improve student learning, as well as facilitate research to increase student achievement and close achievement gaps. (NCES, 2009)

The investment in the SLDSs has removed an important roadblock to data use by educators: the concern that data were not readily available to be examined and analyzed.

Local Data Systems

There is parallel growth of data systems to serve districts, with a substantial investment in the technological infrastructure at the local level, the total cost of which is not well established. Technologies for districts, schools, and classrooms have been an emerging field for a number of years, with the systems being one of the key tenets of data-driven decision making (Hamilton, Halverson, Jackson, Mandinach, Supovitz, & Wayman, 2009). Means, Padilla, and Gallagher (2010) found that almost all districts, except the smallest ones, now have some sort of technology to support data-driven decision making.

The technologies are often inextricably interwoven with the kinds of data that reside in tools (i.e., item level testing data in assessment systems or diagnostic data in handhelds), making it difficult to discuss the specific type of applications without

referring to the characteristics of the data. Wayman (2005, 2007) identifies four main types of systems: data warehouses, student information systems, instructional management systems, and assessment systems. Many other smaller applications also exist; for example, diagnostic devices and data dashboards for real-time decision making.

Standards for Teachers and Leaders

Data literacy is a developing theme in the updated standards for teachers from the Interstate Teacher Assessment and Support Consortium [InTASC] (CCSSO, 2011) and the Interstate School Leaders Licensure Consortium [ISLLC] 2008 (CCSSO, 2008). Data use is directly addressed in the ISLLC standards. For instance, Standard 1 requires administrators to know how to “collect and use data to identify goals, assess organization effectiveness, and promote organizational learning” (CCSSO, 2008, p.14). Data collection and analysis and data use to adapt leadership strategies are addressed in two additional standards. In the InTASC standards, data use is indicated in almost 40 knowledge, disposition, and performance statements that integrate the theme of using data to support teaching and learning across the document.

Clearly there are strong statements coming from federal policy makers about the importance of using data, coupled with substantial investments of federal and local dollars in creating technology infrastructures to support the availability of data. However, the development of human capacity among the nation’s educators to use these systems and applications and to examine data has not been systematically supported. There has not been a coordinated effort to train current and future educators to use data. For example, Means and colleagues (2010) report that over 90 percent of the districts in their sample have provided some professional development, but not for all schools or all

teachers. And it is difficult to ascertain the comprehensiveness and quality of such training.

Current State of Data Literacy Development

The research base supporting the characterization of data literacy skills and knowledge adequately demonstrates the complexity of using data yet there is little agreement about data literacy as a construct (Mandinach & Gummer, 2011b). Educators need multiple experiences to develop data literacy across their careers, from pre-service preparation throughout their career-long development of expertise. The contexts in which educators are prepared to use data in pre-service programs and on the job are not well described.

Characterizing Data Literacy Skills and Knowledge

Multiple researchers have identified the knowledge and skills and the processes or components that undergird data literacy.

- Differentiate instruction to meet the needs of all students (Long, Rivas, Light, & Mandinach, 2008; Love, Stiles, Mundry, & DiRanna, 2008);
- Formulate hypotheses about students' learning needs and instructional strategies (Boudett, City, & Murnane, 2007; Halverson, Pritchett, & Watson, 2007; Herman & Gribbons, 2001; Love, et al., 2008; Mandinach, et al., 2008);
- Collect and use multiple sources of data (Bernhardt, 2008; Goldring & Berends, 2009; Kerr, Marsh, Ikemoto, Darilek, & Barney, 2006; Love, et al., 2008; White, 2005);

- Use formative, summative, interim, benchmark, and common assessments to make decisions, as well as student classroom work products (Boudett, et al., 2007; Goldring & Berends, 2009; Love, et al., 2008; White, 2005);
- Modify instructional practice according to the data collected (Abbott, 2008; Bernhardt, 2008; Mandinach, et al., 2008);
- Drill down to the item level to gain a deeper understanding of performance (Boudett, et al., 2007; Love, et al., 2008);
- Use student work, not just tests, and other sources of data (Bernhardt, 2008; Boudett, et al., 2007; Halverson, et al., 2007; Supovitz & Klein, 2003; Wayman & Stringfield, 2006);
- Monitor outcomes (Easton, 2009; Love, et al., 2008; Mandinach, et al., 2008);
- Focus on all children, not just the “bubble kids” (Booher-Jennings, 2005; Brunner, Fasca, Heinze, Honey, Light, Mandinach, & Wexler, 2005; Love, et al., 2008);
- Look for causes of failure that can be remediated (Boudett, et al. 2007; Love, et al., 2008); and
- Work in data teams to examine data (Halverson, et al., 2007; Long, et al., 2008).

Administrative data literacy requires many of these same skills but integrates educational leadership and management skills. Some of the skills mentioned include: planning for data use; preparing for group structures; understanding and allowing for collaboration (Chen, Heritage, & Lee, 2005; Halverson, Gregg, Pritchett, & Thomas, 2005; Lachat & Smith, 2005; Supovitz & Klein, 2003); establishing a vision for data use (Hamilton, et al., 2009); aligning learning goals with available data; and providing for

distributed leadership (Lachat & Smith, 2005; Park & Datnow, 2009). Knapp, Swinnerton, Copland, and Monpas-Huber (2006) noted that there is little understanding of how administrative data literacy is defined.

Data literacy is often confused with assessment literacy, though the distinctions between the two have not been clearly explicated in the research literature. There is no doubt that understanding assessment is an important component in data-driven decision making (Brookhart, 2001; Heritage & Yeagley, 2005; Herman & Gribbons, 2001; Popham, 1999; Shaw, 2005). Yet assessments as data collected from classroom, school, district and state measures of student achievement are only one type of data that enter into the decision-making process. Data literacy requires knowledge of other data, such as perception, motivation, process, and behavior. Thus, the field needs to refine what is meant by data literacy and skills and knowledge needed to engage in data use and a variety of data (Mandinach & Gummer, 2012a) to reduce the confusion with assessment literacy.

Current Practices at Universities and in Professional Development

Secretary Duncan (2012) has challenged schools of education to step up and meet the growing need to improve current and future educators' data literacy. He has stated that the institutions must help prepare educators to use data more effectively than they have done in the past. While there is a growing emphasis from policy makers, there is little reliable evidence regarding the extensiveness of courses on data-driven decision making and what schools of education are doing to respond to the new federal emphasis on this practice.

The research and practice literature consistently discusses the lack of human capacity around data use (Choppin, 2002; Feldman & Tung, 2001; Hamilton et al., 2009; Herman & Gribbons, 2001; Ikemoto & Marsh, 2007; Mandinach, 2009; Mandinach & Honey, 2008; Mason, 2002; Miller, 2009; Wayman & Stringfield, 2006), but to date there is no systematic empirical evidence about the prevalence of course offerings in schools of education that can address the development of data literacy other than a small and limited survey (Mann & Simon, 2010). We know that courses are only now beginning to emerge. Some courses are limited to graduate-level seminars for administrators (J. Wayman, personal communication). Such courses are often small in size and highly focused. Some courses have broad reach by using a virtual portal (B. Bellucci, personal communication; Mann & Simon, 2010). Undergraduate courses for teacher candidates seem to be sporadic, most often with instruction on data-driven practices subsumed in existing offerings such as measurement, statistics, instruction, or methods.

There are examples of successfully integrating data-driven decision making through a school of education's curriculum. Western Oregon University has a pre-service curriculum infused with data-driven concepts where the faculty members are expected to use data and evidence to inform teaching and learning (H. Rosselli, personal communication). A culture of evidence has been created, and faculty must use data-driven principles in their teaching. Professors model data-driven decision making by: (a) collecting baseline data; (b) using those data for course improvement, as well as identifying student learning needs; (c) modifying instruction based on the data; and (d) assessing again to determine impact. Data link proficiencies to performance to create a cycle of continuous improvement. Faculty members explicitly model this process and

expect their students to do their same in their practice. Student practica require the use of real-time data. In over nine years through strategic hiring, this institution has transformed itself into a learning organization with a culture of evidence in which data serve as the impetus for change.

University faculty also can adopt examples and methods used by professional development providers that have programs for in-service educators. There are many opportunities, topics, and techniques that can be generalized to formal courses or strategically integrated into existing courses from these training models. There is also a current effort to understand the characteristics of these programs and the missing components (Mandinach & Gummer, 2012b).

Helping educators to gain data literacy requires a developmental approach to skill acquisition. Most of the attention to date has focused on training the current cohort of teachers and administrators through in-service and professional development opportunities. Typically principals are trained first, and then using a turnkey model, teachers are trained (Mandinach, 2009). There is anecdotal evidence that course offerings for administrators are more prevalent than for teachers. Yet the field lacks concrete evidence of how course offerings differ across the spectrum from pre-service to post-graduate levels (Mandinach & Gummer, 2012b) or how courses on data-driven decision making should differ at different points in educators' careers (Mandinach et al., 2011).

The Need for a Systems Approach to Build Data Literacy Among Educators

Systems thinking attempts to understand the interrelationships among components in complex systems. It serves an integrative function to address a complex problem such as the building of data literacy for educators. It allows organizations or institutions to

focus on the whole, rather than individual components of the system. With systems thinking, organizations examine the structure or the interrelationships among components that influence behavior over time. System thinking recognizes the hierarchical nature of phenomena and operation within multiple levels, such as schools within districts within states (Mandinach & Cline; 1994; Mandinach, Rivas, Light, & Heinze, 2006; Senge, 1990; Senge, Cambron-McCabe, Lucas, Smith, Dutton, & Kleiner, 2000; Williams & Hummelbrunner, 2011). Senge's framework examines wholes with respect to change, and looks at the complexity of interactions among system components, identifying underlying structures and causes. A systems approach helps organizations to identify leverage points and determine where and when actions can be taken to affect change. Systems thinking also relies on the systematic collection and analysis of data for self-reflection and considers the consequences of decisions.

Stakeholders and Their Roles

The first step in characterizing the systemic nature of improving the use of data by educators is a characterization of the key stakeholders in the system. Our articulation of the stakeholders and their roles and responsibilities arose from the convening of researchers, deans, and accreditation experts (Mandinach & Gummer, 2012b). The objective of this Spencer-funded meeting was for stakeholders to discuss issues around how data-infused courses could be implemented in school of education

Schools of Education

Schools of education are a key stakeholder in improving educator data literacy by integrating data-focused courses or concepts into educator preparation programs. We envision an enhanced role for schools of education, introducing data literacy early and

affirming its importance throughout an educator's career to support the enculturation of data use.

School Districts and Practitioners

Schools of education are not the only stakeholders in the efforts to improve educator data literacy. A second stakeholder in the system is the school district and the practitioners actually carrying out the requirements of data use. Districts employ educators who may lack the skills and knowledge around data use, but who must acquire the capacity to use data. Districts may seek help from schools of education because they lack the resources or the internal capacity to implement broad-scale training on data-driven decision making. Districts look to schools of education for courses for their current staff. They can look to the schools of education to produce new teachers who have data skills and show competence in data use (Mandinach, et al., 2011; Mandinach & Gummer, 2012b). Some districts require candidates for positions to demonstrate data literacy as a requirement of the hiring process (Long et al., 2008).

Professional Development Providers

Experts in professional development are another stakeholder with a history of working with practicing educators to help them develop understandings of data-driven practice. Schools of education can learn from the professional development providers about how to develop courses on the topic or how to integrate data-driven concepts into existing courses. Schools of education could even look to the professional development providers as a resource in teaching courses, including face-to-face courses, virtual courses, or for continuing education credits. Schools of education do not have to hire additional faculty or allot a faculty position to someone who knows data. Professional

developers can broaden their range of influence. Most importantly, more educators will be introduced to data-driven practices and become data literate.

State Education Agencies

States and their credentialing agencies can have a major impact on the introduction of courses on data-driven decision making if they expand and make explicit requirements that schools of education prepare educators on data use. Schools of education will have to respond to such requirements in state licensing and accreditation rules. According to a self-report survey of state data directors, results indicate that 10 states have requirements for data training for superintendents, 13 for principals, and 14 for teachers (Data Quality Campaign, 2011, 2012). Only 11 states require data literacy as a part of the pre-service credential/licensure process.

Professional Organizations

Other organizations have critical roles in helping to establish data-driven decision making in educator preparation, driving the need for more systematic preparation in data literacy for educators with accreditation and licensing regulations. Professional organizations such as the National Board for Professional Teaching Standards (NBPTS), the National Council for Accreditation of Teacher Education (NCATE), and the American Association of Colleges for Teacher Education (AACTE), can provide an impetus for creating change, explicitly emphasizing data literacy in standards and evidence for accreditation. For instance, NCATE's Blue Ribbon Panel (2010) released a comprehensive set of recommendations for the future of teacher preparation that are far-reaching and are intended to have a direct impact on training educators to use data. The Panel states that teacher candidates, "need to have opportunities to reflect upon and think

about what they do, how they make decisions, and how they ‘theorize’ their work, and how they integrate their content knowledge and pedagogical knowledge into what they do” (p. 9). The report further states that teacher preparation must provide “the opportunity to make decisions and to develop skills to analyze student needs and adjust practices using student performance data while receiving continuous monitoring and feedback from mentors” (p. 10). These are the principles of data-driven decision making and continuous improvement applied to teacher preparation and to practice.

CCSSO has a wide range of activities, some of which can target the importance of the use of data and training educators to use data. CCSSO convenes meetings of top educational officials who can influence change in their states by initiating discussions that may lead to the inclusion of data literacy among licensure and certification requirements. Consortia supported by CCSSO can include among their standards more explicit references to data literacy skills as they apply to the professions. The challenge is making the standards operational.

Testing organizations can integrate data-driven concepts into their assessments for teachers and administrators at the behest of licensing agencies. If the assessments are a required part of the credentialing or licensure process, then schools of education are likely to respond by ensuring their students are prepared for the examinations. Currently, data-driven decision making is not part of the *PRAXIS* test, but it is included in the *School Leaders Licensure Assessment*. The latter requires data-driven decision making through the analysis of different sources of data and information to form a decision (Educational Testing Service, 2005). We suspect that if data-driven decision making is required on tests for teachers and administrators, schools of education will be forced to

respond by teaching to the test. Testing companies will build such assessments if professional organizations and states require such skills and knowledge.

U.S. Department of Education

Finally, the federal government can play more of a role in emphasizing the need for data literacy beyond the speeches government officials have made. To date, there is neither a federal mandate nor specific funding programs to stimulate the training of educators. Although substantial funds have been devoted to the development of the technological infrastructure, no monies have been similarly devoted to building the capacity of educators to use data to improve teaching and learning.

What Needs to Happen

We have emphasized three fundamental premises. First, data-driven decision making must become part of an educator's preparation. Educators must receive systematic training in how to use data, preferably beginning in their pre-service years, but continuing throughout their careers. Second, schools of education are the appropriate venue in which the needed educational experiences must occur. Schools of education must find ways to integrate data-driven practices and principles into the training of educators. Finally, we have discussed the roles of many of the key players we see as creating an environment for change.

It is reasonable that schools of education must be the driving force for improving data literacy as the pre-service preparation period is a major opportunity for the development of knowledge and skills. However, the introduction of a data-use focus into programs or courses may not be simple. It is unclear if there is sufficient motivation or perceived needs on the part of schools of education. It is unclear whether current faculty

members are sufficiently data literate to be able to teach such courses. A related issue is whether or not deans of schools of education believe that having a faculty slot devoted to data-driven decision making is important. This is an issue of perceived need as well as prioritization. Other priority and pressing university needs may trump such appointments (Mandinach, et al., 2011).

There is little agreement whether it is best to have stand-alone courses or if data concepts should be subsumed within existing courses. Questions abound about if and how data use should be integrated into practica so that candidates can gain experience working with authentic data. What is the most effective format of courses or integrated concepts to educate them on the topic? Further, how do these decisions differ for courses aimed at administrative candidates? When is the right time to integrate data-driven decision making (Mandinach & Gummer, 2012b)?

Many questions still remain about how best schools of education and other agencies can respond to address the growing need to build capacity among current and future educators to use data (Mandinach et al., 2011). Our recommendations for stimulating progress in the field focus on two areas of need. First, there is a need for research to address the gaps in the scientific knowledge base help us understand the changes that need to occur in educational practice. Second, representatives, policy makers, and decision makers need to come together to discuss and work out the action steps necessary to ensure that educators know how to use data to inform their practice.

Research Needs

Research on Current Practices

As described in the previous sections, a major gap in the field's knowledge about data-driven decision making is how educators currently acquire data literacy. The lack of knowledge of what courses exist and if and how schools of education are attempting to address the growing need to build human capacity around data use hampers the development of systematic processes for improvement.

There is a clear need for a scientific and comprehensive survey and inventory of the existence of courses and the extent to which data-driven practices are integrated into existing courses is needed. This need was made explicit during the meeting of experts on which this article is grounded (Mandinach, et al., 2011). Such a survey is planned for the 2012 academic year (Mandinach & Gummer, 2012b).

Additionally, it is necessary to understand how states are dealing with the issue. Researchers and policy implementers need to know what accreditation and licensure requirements around data literacy have been issued by the states, how those requirements are being implemented, and how institutions of higher education are responding. The information from such a comprehensive survey and inventory will provide fundamental data from which policy organizations and schools of education can build and respond. Currently, there is only anecdotal information that is insufficient and even inappropriate, given that is the policy and practice emphasis on the importance of data-driven practice.

Research on the Impact of Data Use

Another gap in the field's knowledge base is whether the use of data changes classroom practice and ultimately student performance. A recent study (Carlson, Borman, & Robinson, 2011) found mixed results for mathematics and reading achievement from a district-wide data-driven reform intervention. The field still needs to more clearly

understand what impact there might be at the student and teacher levels as well, including the intended and unintended consequences.

Research on Policy

There are several policy-oriented issues to be addressed and better understood. First and foremost, there needs to be an alignment between what districts, schools, and educators actually do and need and the actions that schools of education might take to integrate data-driven practices into educator preparation programs. It would be remiss to make changes without consulting the ultimate stakeholders and end users – local education agencies. Schools of education should be responsive to those needs, whether adapting their course offerings or providing outreach through continuing education opportunities.

There is a need to explore the role that the states can play in setting future policy and developing and mandating licensure and certification requirements for all educators, and to address the following: (a) can and will states require that educator preparation programs offer training on data use?; (b) will schools of education be held accountable for their graduates to show evidence of data literacy?; (c) can and will testing organizations introduce components of assessments that measure data use and data literacy?; and (d) will such requirements stimulate change throughout the education system and impact practice?

The role the federal government might play beyond making public policy statements about the need for educators to be data literate should be addressed. A policy analysis might address: (a) if there provisions can be provided for helping to train the

current cohort of educators; and (b) what the U.S. Department of Education can do. A parallel policy analysis research might also address the roles that states can play.

Research on Developmental Needs of Educators

We still do not understand the differing needs of diverse groups of educators in terms of preparation for data-driven practice. Research is needed to understand data literacy preparation needs of teachers as opposed to administrators and of novice as opposed to experts. As noted above, educators' needs will differ and the field can benefit from understanding those differences and how best to provide education and training on data literacy to address the diversity.

Strengthen the Discourse Around Educator Preparation

This article has discussed the complexity of infusing data practices into the preparation of educators. The research we recommend above is a necessary but insufficient component of improving data literacy. What also is needed is high-level support from policymakers and relevant stakeholders. It is not clear where and how data-driven courses can and should be integrated into course work. This is, in part, because of the diversity of needs across pre-service to in-service, and teachers to administrators.

Continued discussion among the relevant agencies can help to address some of the questions and issues we have identified. It is our belief that change will not happen if each agency functions in isolation without a more comprehensive approach to the issue. The meeting that we convened in 2011 (Mandinach, et al., 2011) brought together some but not all necessary participant groups. A more comprehensive and higher-level meeting is needed where officials from federal and state education agencies, the professional education organizations, deans of schools of education, credentialing organizations, and

other interested parties come together to not just discuss what needs to be done to affect change, but actually map out policy changes that will necessitate and create the change that is needed.

Bringing together stakeholders who can make action happen may be an effective means by which progress can begin to occur. The development of a systemic, comprehensive, and strategic plan is needed. If the field is left to a piecemeal approach to action, nothing is going to happen and little, if any, progress will be realized. This issue requires buy-in from many, at different levels, and from varied organizations. Obtaining that agreement requires leveraging at the appropriate sources of influence. It will not be easy because of the interdependencies and complexities, but it is possible.

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