Paper Title A Human Factors Engineering Framework for Effective Data Use in Education Reform and Accountability

Author(s) Sara Kraemer, University of Wisconsin - Madison

Session Title Data Use for Accountability: When Reforms Meet Reality

Session Type Session Paper

Presentation Date 4/9/2011

Presentation Location New Orleans, Louisiana, USA

Descriptors

Methodology

Unit Division H - Research, Evaluation and Assessment in Schools

A Human Factors Engineering Framework for Effective Data Use in Education Reform and Accountability

Sara Kraemer

Wisconsin Center for Education Research

University of Wisconsin–Madison

INTRODUCTION

District- and school-based accountability efforts continue to expand in dimensionality and breadth in the U.S. education reform movement. This expansion has included student testing for multiple grades and subjects areas, as well as an increasing emphasis on high-stakes accountability (e.g., teacher merit pay, tenure reform). Central to performance-based accountability is the effective use of data at the school level to inform instructional decisions that support student learning. However, an Institute for Educational Sciences (IES) panel on the use of student achievement data for instructional decision-support conducted a systematic review of literature and found that the existing research on using data to make instructional decisions does not yet provide conclusive evidence of "what works" to improve student achievement (Hamilton et al., 2009, pg. 6). The panel recommended a framework for using data to make instructional decisions; some of the recommendations included human and organizational factors, such as the use of data teams, collaboration structures, incorporation of the user (i.e., student) in data

analysis and goal setting, and an inter-dependent approach (i.e., classroom, school, district integration) to manage school improvement.

But educators need not only the right data, but also the right conditions for its effective use to promote school success. However, the research base on data-driven decision making in education is limited in what it has to say about those conditions. The existing research reflects the current accountability context, and in particular, an underlying assumption that if educators are given access to standards-based accountability data (standardized tests, student and educator evaluations, and other performance indicators), they will use it effectively to inform their practice and thereby improve student achievement. This assumption has impeded the development of more robust analytic approaches to use of data for instructional decision making and school improvement, or even the investigation of the human and organizational factors that shape educators' uses of data. As a result, we lack the most basic descriptive information about how data are used in classrooms and schools.

One pathway to address the concerns raised in the IES panel and the gaps in the current accountability-based context is to apply the approaches, methodologies, and frameworks developed in human factors engineering. Human factors engineering is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (International Ergonomics Association, 2011). A human factors approach in education also embodies quality and systems management principles, methods, tools, and processes at every level of a school district (American Society for Quality Standard, 2002). The application of a human factors approach to effective data use in schools may increase the effective enhance the design and implementation of school- and district

improvement efforts. I also posit that a well-developed human factors approach to education policy and programs may increase the potential for positively affecting student performance at the district-, school-, and classroom-levels.

In this paper, I present a human factors framework of school performance and effective data use in schools. The framework will be substantiated with 2 case studies of a high and a low performing school in Milwaukee Public School (MPS) District. These cases are drawn from our exploratory study of effective data use across range of high and low performing schools in MPS (Kraemer, Geraghty, Lindsey, & Raven, 2010). The aim of this paper is to demonstrate the viability of a human factors framework for conceptualizing and describing school-level data use from a multi-factor, holistic perspective.

BACKGROUND

To date, the small but growing body of human factors (also known as ergonomics) research in education has focused mainly on classroom environment issues. The Ergonomics for Children and Educational Environments (ECEE), a technical committee of the International Ergonomics Association whose objectives are to prevent or reduce the possible risks of developing musculoskeletal and vision disorders and to promote the beneficial effects of educational computing and environments (ECEE, 2011), have identified a range of human factors research topics related to primary education. These topics include anthropometrics and design of classroom furniture, computer use of students, computers and vision, backpacks and carrying cases, low back issues in children and adolescents, curriculum, educational environments and information technology, teacher issues, children safety issues, and general

design and ergonomics issues with children. These studies demonstrate that education is amenable to human factors engineering research, but are representative of a fractionalized approach that either focuses on a single factor, such as anthropometrics, or a small group of factors such as educational environments and information technology. A fully-developed human factors approach to effective data use emphasizes a systemic and holistic analysis of factors as a school system.

Human factors in education has focused on district and school data use, processes, and structures and has emphasized the adoption of quality management practices at the school level. The three primary quality management frameworks adopted in education are the Baldrige Educational Criteria for Performance Excellence (Baldrige National Quality Program, 2010), the International Standards Organization's (ISO) 9000 standards in education series (American Society for Quality Standard, 2002), and Total Quality Management (Bonstingl, 2001; Garbutt, 1996). Though, the quality management approach in education does not fully integrate human factors, such as job content and design, human-system design and integration, task-person fit, and team performance.

Data use, or "data –driven decision making" is a research stream that shares some of the system characteristics necessary for effective human factors at the school level. School leaders and teachers are expected to effectively use data to inform school- and classroom-level improvements and evaluate their practices (Hamilton et al., 2009). However, the quality of data available and the effectiveness of schools' capacity to use data for instructional improvement vary. Schools and districts collect many forms of student data (e.g., attendance, behavior, coursework, grades, state-administered test results) as well as administrative data (e.g., staffing, scheduling, finance data), but it is rare for school leadership and teachers to use data to determine

the root causes of reoccurring problems and analyze the impact of initiatives and programs (Tolley & Shulruf, 2009). Further, school leaders often conduct or evaluate their education programs on gut feelings with little formal analysis of how well those programs work and do not perform long-term planning for student improvement over time (Bernhardt, 2004).

Becoming a "data-driven" school is not just a technical endeavor; human factors also contribute to effective use of data and knowledge creation for school and classroom improvement. School leaders and teachers are expected to work in team-based structures and collaborate across classrooms and grades to analyze data, design strategies, and implement improvements within various organizational conditions that also vary in school types. However, a recent review of the educational administration literature revealed that theory and research in school-staff teams lags far behind the current team models in organizational theory (Somech & Drach-Zahavy, 2007).

Yet, there is a strong need for sound organizational and team-based models that fit with the characteristics of school leaders and teachers, teams, task-structures, and school organization design. For example, tasks are often structured for the individual teacher. Teachers work within their classrooms with a high degree of autonomy and isolation from colleagues (Levine & Marcus, 2010). The transfer to team-work often encompasses incompatible goals and conflicting interests (Somech & Drach-Zahavy, 2001). Further, teachers typically teach in their classrooms individually, with limited opportunity to interact with colleagues to exchange information and cope with problems. In such a structure, teachers learn to work alone, rely on their personal talents and skills, and manage problems that arise in their classroom on their own.

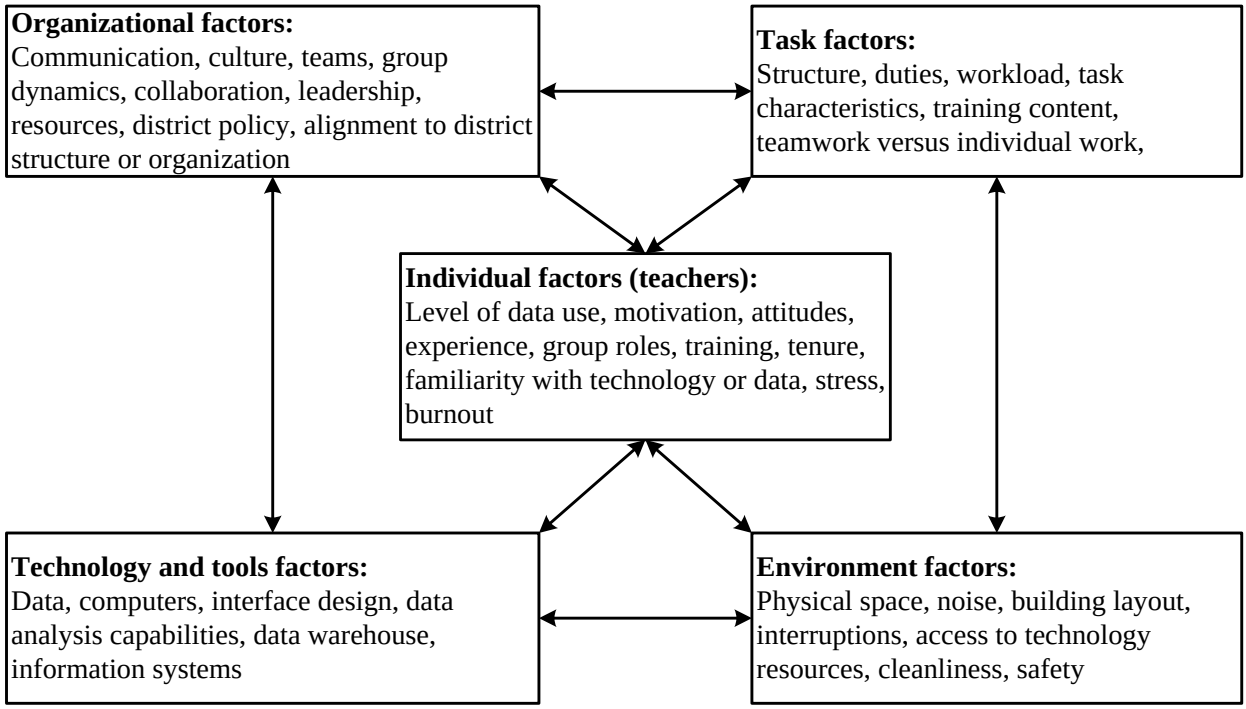
This brief literature review outlined some of the potential key "mis-matches" among the characteristics of the teaching environment, teacher task and workload, teaching job design, and

use of data, as well as some gaps in knowledge as to how to design systems that effectively support teacher-level decision making. The next section presents a human factors framework for conceptualizing the school work system, with a particular emphasis on the use of data for effective decision making at the teacher level. One of the key purposes of the human factors framework is to highlight how the "mis-matches" among the characteristics of the learning environment, individual teachers, and nature of teaching tasks may used to inform the the effective design and implementation of work systems that support effective decision making in schools and classrooms.

A HUMAN FACTORS FRAMEWORK FOR EFFECTIVE DATA USE

Figure 1 provides a visualization of the human factors that comprise the "work system" of schools (Carayon & Smith, 2000). The school work system is conceptualized as comprising five groups of factors: *individuals* (e.g., teachers or teacher teams) who engage in a variety of *tasks* (e.g., duties, workload, task characteristics) within an *organizational* context (e.g., culture, leadership, collaboration) and *environment* (e.g., building layout, noise), mediated by *technology and tools* (e.g., student data, computers, information systems). The *interplay* among these factors creates conditions that shape the processes of using data for instructional decisions and highlights how various factors in the school work system may shape the performance of teacher and teacher teams.

Figure 1. Human factors framework of data use



METHODOLOGY

Study design and sample

The case studies described in this paper are culled from a study on data use in Milwaukee Public Schools (Kraemer et al., 2010). The overall study adopted an exploratory approach and used a field-based, qualitative design. The study consisted of cross-case analysis of eight schools. Semi-structured interviews with principals and non-participant observations of "learning team" meetings were conducted at each school. Learning teams are groups of school leaders and teachers tasked with, among other responsibilities, analyzing data and planning school improvement efforts.

This study was conducted in collaboration with Milwaukee Public Schools (MPS). MPS is a large, urban district that serves 82,444 students in southeastern Wisconsin. MPS has been designated a "District Identified for Improvement" (DIFI). The DIFI status reflects the district's failure to meet reading and math attainment standards since 2004, as defined by NCLB. Given the urgency to improve district performance under the DIFI designation, we were particularly interested in high- and low-performing school comparisons.

We defined performance at the school-level via value-added analysis. Value-added (VA) analysis measures school productivity and the contribution of schooling to growth in student achievement. It consists of statistical techniques that separate the impact of schooling from other non-school factors that may influence growth (Meyer & Christian, 2008). MPS uses attainment scores on the state test to designate schools as high- or low-performing. However, attainment is not a productivity measure like VA; it does not filter out prior academic achievement, student mobility, or other factors like race and socioeconomic status.

To address this discrepancy, we used a comparison of VA and attainment measures to select 2 schools that vary in student performance. The first school (School A) was a high VA/low attainment and was defined as a high performing school; this school received students that tested very low on the state test and did not make the mandated proficiency goal, but their academic performance grew faster than the district average. This school served grades K-5. The second school (School B) was a low VA/low attainment school was defined as a low-performing school. The low VA/low attainment school served grades 5-8 and was a charter school.

Data collection and analysis

The interview and observation data was collected at schools during normal school-day hours from October 2008–February 2009. One-hour, semi-structured interviews were conducted with

the principals and their responses were captured via hand-written-notes by the interviewers. The notes were electronically transcribed, stripped of identifiers and saved in a password-protected network. The interview guide consisted of global question and probes about the dimensions of data and data use and questions about human factors, based on the five-factor work system framework consisting of the individual, organization, tools and technologies, environment, and task (Carayon, 2009).

We also observed learning team meetings at each school. These were regularly scheduled meetings of school leaders and teachers to plan school-based initiatives, review programs, and analyze data. We used the same work system framework to observe macroergonomic factors, types of data used at the school level, and how data analysis was performed in the learning team settings. The observers captured their interviews via handwritten notes and followed the same study procedures taken for the principal interviews.

We performed a content analysis on the data set using QSR NVivo©, a qualitative analysis software package, to organize the themes and code responses. The thematic coding structure consisted of an *a priori* skeleton structure based on the research questions and five-factor work system framework. One researcher coded the responses and the other performed inter-rater reliability tests by coding transcripts and making cross-case analyses of the categories and coding created by the first researcher. The differences in coding consisted of clarifications in definitions.

APPLYING WORK SYSTEM FRAMEWORK IN HIGH- AND LOW-PERFORMING SCHOOLS

School A was a high VA, low attainment, K-5 school in the Milwaukee Public School District. School B was a low VA, low attainment, 5-8 school. Both schools served students populations that were largely minority students, and had high levels of ELL and free- and reduced lunch students.

Organizational factors

School A (high value-added, low attainment school) used their status as a National Educational Association (NEA) Focus School to create "a sense of urgency" to improve student learning. NEA Focus Schools were schools below the district average in attainment the past 4 years in at least one grade span. As an NEA Focus School, School A received an additional 2 teachers, professional development, teacher coaching, and a "curriculum generalist" position. The curriculum generalist worked with teachers to oversee teaching and learning for the school. This role included ensuring the implementation of classroom curriculum, administration of benchmark tests and the Wisconsin Knowledge and Concepts Exam (WKCE, the annual, state-administered test), education programs, and other school-related improvement initiatives. During the principal's 5-year tenure, the NEA Focus School designation occurred during the first year of his administration. The new organizational form that resulted from the NEA Focus School designation was one that expanded the administrative leadership team (to include the curriculum generalist position) and placed a greater emphasis on the principal as an instructional leader. Learning team meeting activities at School A included teachers, the curriculum generalist, and teachers from each grade-level. The meeting included an agenda, list of action items, and follow-

up to ongoing data analysis for reading improvement (reading programming and data was the topic of discussion at this school).

The organization of School B emphasized a military approach to schooling, where the school implanted programs to promote self-discipline via a military protocol. School B's approach was to mitigate behavior-related issues over academic goals. The principal in School B was newly appointed and in his first year of administration. The principal was not yet part of the learning team at the school and had not yet developed an approach to school improvement planning within the school (i.e., as part of the learning team process to school improvement, goal planning). The learning team at School B was a loosely coupled team of 5 teachers (the current principal was not present at the meeting). The meeting lacked agenda items or structure, and took a "check-the-box" approach to topics regarding school improvement. The team seemed to lack cohesiveness and direction for goal-setting.

Task factors

School A task factors included both individual and team-level tasks. At the individual level, teachers are responsible for implementing their curriculum, administering exam and course tests, and interpreting the results of the student test scores to inform on-going teaching and curriculum decisions. The curriculum generalist and principals provided administrative support the design and implementation of teaching and learning. At the team-level, teachers, the curriculum generalist, and principal collected, analyzed, and interpreted student-level data to inform both curricular and school-improvement decisions. The learning team meetings provided the venue and opportunity for team-level task coordination to take place.

School B task factors were less developed than School A's. At the learning team meeting at School B, the task coordination for learning and teaching improvement was not defined nor

was it goal-oriented. The principal articulated the overall goals of the schools as a place to mitigate student behavior, but the academic performance of the students was not emphasized as a key goal. The lack of organizational leadership for academic performance may be part of the lack of task coherence for teachers coordinating their teaching and learning school initiatives.

Individual factors

While School A was designated a NEA Focus School because of 4 years or more of low attainment scores, they demonstrated high VA growth. The NEA Focus School designation served as a catalyst for the school teams to accelerate student performance, which made them more focused on data and data analysis (with the assistance and support of the curriculum generalist). They also viewed their own performance differently, especially as it related to overall student performance. They viewed their high value-added scores as a validation that they are indeed contributing to gains in student learning, although the attainment-determined NEA Focus School designation rateed them as low-performing. The individual skills, perceptions, and abilities for data analysis and school improvement were reported as "enhanced" by the urgency created by the NEA Focus School designation. School A also demonstrated individual reflection about why they were high VA school; one reason may be that they have developed a culture of data to inform better instructional practice.

School B's teachers demonstrated a less-developed understanding of data and there were several discrepancies noted by the research team. In a particularly noteworthy instance, the teachers at School B mistakenly referred to the WKCE as the "national test". While the focus of the learning team meeting at School B was supposed to be on data analysis and recent test scores from the WKCE, it was not clear from the observation of the learning team meeting that the teachers understood the data they were attempting to interpret. Further, they blamed the high

mobility rate of the students for low scores. MPS's value added metric controls for student mobility from school to school, though the team did not consider this in their perception of student performance.

Tools and technology factors

School A used a breadth of tools (e.g., data) and technologies (e.g., aids for data analysis and interpretation, computer, district data warehouse). School A used both short- (e.g., lesson progress charts, monthly reading assessments) and long-cycle data (e.g., WKCE proficiency scores, VA results) to track their students' progress over time and make mid-course adjustments. They also used the topic-specific analysis within the WKCE to identify areas of content improvement within the school. The learning team used benchmarking for reading and math to track student progress over time. Within their own school improvement planning, School A also used the district-mandated "School Improvement Plan" to assess and plan out the school's activities for learning. School A used the district warehouse to obtain their WKCE scores and used technologies like Moodle to support their team collaboration online.

School B seemed to use data as more a reference guide, rather than a tool to drive school improvement. Within the learning team meeting, there was confusion among the teachers as to if they were reviewing benchmark data or WKCE data. There was also a lack of follow-up as to "what to do next" in light of the low test scores. Their low VA results were not discussed and the principal was not aware of their VA score. The emphasis on student behavior may have driven focusing on student academic performance to the backburner. School B did not reference any systematic use of technology to support their school improvement learning, nor did they reference the use of the district-mandated annual "School Improvement Plan".

Environmental factors

Schools A and B both served a largely minority population with urban, inner city problems, such as gangs, violence, and poverty. Both schools acknowledged the importance of student safety and behavior, but the ways the two schools handled academic performance were much different. School A did not view student growth as separate from student safety and behavior goals, while School B emphasized student behavior at the over (or in place of) academic performance goals. The response to environmental factors are shaped by the other factors in the school work system, and what resulted was two different approaches to school improvement and data use, though both schools served similar student populations.

DISCUSSION AND CONCLUSION

This exploratory study demonstrated the viability of applying human factors engineering concepts to the domain of education as it relates to data use as reform initiative. The work systems framework is a descriptive vehicle to articulate the multitude of factors that shape school data use, and emphasized the *interaction* of the system factors and their relationships to one another.

Elements of the school work system highlighted some "mismatches" between tools (data) and technologies (data analysis) and how the work of data-informed improvement was carried out by school staff. For example, there were also variances in between School A and School B's learning team performance, organization, and goals, which may have reflected the "misfits" among teacher job characteristics, team-based collaboration expectations, and school leadership emphasis for school improvement.

Human factors engineering can make contributions to the evolution of data-informed school improvement in several ways. First, team-based organizational models could be adapted and developed for the learning team approach to school improvement; those models need to account for the realities and constraints of teachers' workload, task/teaching composition, and training developments. Developing organizational and job design methods for teachers and school leaders could also be one way to reconcile the mismatches between teacher job design and collaborative, team-based approaches for school improvement. Second, school leadership approaches could benefit from adopting a top-down, whole-systems approach for school functions across the organization. Finally, a human factors approach to communicating productivity metrics, such as VA, could assist in the accurate recognition of school performance (for example, cross-school comparisons, networks of schools with similar student characteristics but which differ on productivity scores). The VA/attainment comparison metric could be one way to differentiate school performance and provide differentiated support to schools based on their performance needs.

This study has several limitations. First, this study consisted of a small sample of schools. The findings are not generalizable, but could be compared to other schools or districts with similar characteristics. Second, the data collection methods included one principal interview and a single observation of a learning team meeting at each school. Future research in this area could expand to include more schools and data collection points with school leaders, and study methods to more fully capture how school-based performance planning is accomplished via interactions among school leaders, teachers, and students.

ACKNOWLEDGEMENTS

This research was funded by the U.S. Department of Education - Institute of Science (Grant # R305A080038, PI: Robert H. Meyer) and the Joyce Foundation.

REFERENCES

American Society for Quality. (2002). Quality management system: Guidelines for the application of ANSI/ISO/ASQ Q9001-2000 to educational or training institutions (ASQ Z1.11-2002). Milwaukee, Wisconsin: American Society for Quality.

Baldrige National Quality Program. (2010). Education Criteria for Performance Excellence. Gaithersburg, Maryland: National Institute for Standards and Technology.

Bernhardt, V. L. (2004). *Data analysis for continuous school improvement* (2nd ed.). Larchmont, NY.

Bonstingl, J. J. (2001). *Schools of Quality* (3rd ed.). Thousand Oaks, CA: Corwin Press, Inc.

Carayon, P. (2009). The balance theory and work system model... Twenty years later. *International Journal of Human-Computer Interaction, 25*(5), 313-327.

Garbutt, S. (1996). The transfer of TQM from industry to education. *Education + Training, 38*(7), 16-22.

Heinrich, C. J. (2007). Evidence-based policy and performance management: Challenges and prospects in two parallel movements. *The American Review of Public Administration, 37*(3), 255-277.

Institute for Educational Sciences. (2009). Using student achievement data to support instructional decision making. Washington D.C.: U.S. Department of Education.

Levine, T. H., & Marcus, A. S. (2010). How the structure and focus of teachers' collaborative activities facilitate and constrain teacher learning. *Teaching and Teacher Education, 26*, 389-398.

Meyer, R. H., & Christian, M. S. (2008). Value-added and other methods for measuring school performance *Performance Incentives: Their Growing Impact on American K-12 Education* (pp. 2008-2017). Nashville, Tennessee: Vanderbilt University.

Milanowski, A. T. (2004). The relationship between teacher performance evaluation scores and student achievement: Evidence from Cincinnati. *Peabody Journal of Education, 79*(4), 33-53.

Milwaukee Public Schools. (2010). Milwaukee Public Schools Homepage, from http://mpsportal.milwaukee.k12.wi.us/

Somech, A., & Drach-Zahavy, A. (2001). Influence strategies of principals: Ordinary times compared with times of change. *Journal of School Leadership, 11*, 25-47.

Somech, A., & Drach-Zahavy, A. (2007). Schools as team-based organizations: A structure-process-outcomes approach. *Group Dynamics: Theory, Research, and Practice, 11*(4), 305-320.

Tolley, H., & Shulruf, B. (2009). From data to knowledge: The interaction between data management systems in educational institutions and delivery of quality education. *Computers & Education, 53*, 1199-1206.