Columbia International Publishing
Journal of Continuing Education and Professional Development
(2016) Vol. 3 No. 1 pp. 14-32
doi:10.7726/jcepd.2016.1002
Research Article

Teachers and Data Literacy: A Blueprint for Professional Development to Foster Data Driven Decision Making

Jennifer L. Green[1*], Sarah Schmitt-Wilson[1], Tena Versland[1], Lynn Kelting-Gibson[1], and Gustave E. Nollmeyer [2]

Received: 17 September 2015; Accepted pending minor revisions: 04 November 2015; Received in revised form: 04 March 2016; Accepted: 03 April 2016; Published online: 14 May 2016

Abstract

Standardized testing and the implementation of the Common Core State Standards has brought the importance of data literacy and data driven decision making (DDDM) to the forefront of district professional development needs. Many states currently require school districts to collect student performance data in the pursuit of increasing student achievement. However, most school districts do not have a clear vision for how these data will be used to inform and improve instruction (Creighton, 2006). Moreover, few educators have been trained in DDDM. In this paper, we share our insights and experiences in designing and providing professional development for teams of teachers and administrators in order to establish, support and sustain a data-driven culture within their schools and districts. We begin by discussing the need for DDDM, continue by describing the process of designing and implementing training opportunities for educators, and conclude with a discussion and evaluation of the initiative's success. This research offers practical suggestions for creating a culture of DDDM within schools and districts. Our insights provide important direction for university faculty and school district administration as they seek to develop partnerships where university providers design professional development and outreach opportunities that support student learning.

Keywords: Data Literacy; Professional Development; Data Driven Decision Making; Instructional Improvement

1. Introduction

Standardized testing and the implementation of the Common Core State Standards (CCSS) has brought the importance of data literacy and data driven decision making to the forefront of district professional development needs. A majority of states have adopted the CCSS and districts are required to collect and analyze student data to determine students' proficiency levels in math and

*Corresponding e-mail: jgreen@montana.edu
1 Montana State University
2 Eastern Washington University

English Language Arts (ELA) aligned with these standards. Hence, the need for greater data literacy is upon us.

Data literacy, is defined as the "ability to understand and use data effectively to inform decisions" (Mandinach and Gummer, 2013, p. 30). Mandiach (2012) also suggests that when using data to inform decisions, educators employ data driven decision making (DDDM). DDDM pertains to the systematic collection, analysis, examination and interpretation of data to inform practice and policy in educational settings (p. 71). Presently, little information or opportunity exists that would enable teachers to learn how to better understand and utilize their students' performance data, particularly with respect to the CCSS standardized testing. Deepening educators' understanding of the benefits of analyzing data and using the results to improve instructional practices creates the necessary momentum to successfully implement the CCSS as an agent to increase students' academic achievement.

1.1 Purpose

Many states currently require all districts to collect student performance data in the pursuit of increasing student achievement across all demographics. However, most school districts do not have a clear vision for how these data will be used to inform and improve instruction (Creighton, 2006). Moreover, few educators, including administrators, have been trained in DDDM. The purpose of this research was to examine a process of how school districts could develop a culture of data literacy and DDDM by implementing professional development training for teachers and administrators. Our primary goal was to provide school-based teams of teachers and administrators with data literacy skills and experiences needed to evaluate teaching and learning processes, and to make necessary instructional or programmatic changes for improving student performance. In this paper, we share our insights and experiences in designing and providing professional development for teams of teachers and leaders in order to establish, support and sustain a data-driven culture within their schools and districts. We begin by discussing the need for DDDM, continue by describing the process of designing and implementing training opportunities for educators, and conclude with a discussion and evaluation of the initiative's success. This research strengthens the literature base and offers practical suggestions for creating a culture of DDDM within schools and districts.

2. Review of Literature

In order to establish, support, and sustain a data culture within schools and districts, both administrators and teachers need expertise in DDDM (Means *et al.,* 2011). That is, educators need to know how to summarize data from a variety of sources and transform information gleamed from them into sound instructional strategies and practices that can improve student learning. Yet, "at issue is a dearth of formal and informal mechanisms by which educators can gain the skills and knowledge needed to become data literate" (Mandinach, 2012, p. 77). Data literacy allows educators to efficiently evaluate teaching and learning processes so that necessary instructional changes boosting student performance occur more quickly. Kekahio and Baker (2013) claim, "using data to inform education policies and practices is becoming a greater priority for educators, spurred by…increased accountability requirements…" (p. 1). Although using data to inform

educational policies and practices is important, not all educators possess the data literacy skills necessary to inform their instruction. In a study conducted by the U.S Department of Education (2011), teachers responded to scenarios involving hypothetical student data designed to probe their understanding of the kinds of data available to support their instructional decisions. This proved challenging; specifically the teachers struggled to locate data, recognize different types of data, perform appropriate calculations, interpret data tables and graphs, and implement findings related to improve student learning. Such results highlight a need for professional development in data literacy.

Even though there have been numerous professional development opportunities which discuss the *need* for collecting and analyzing data, few, if any, professional development opportunities have been able to demonstrate how to analyze data and interpret the results to improve classroom practice (U.S. Department of Education, 2011). Mandinach (2012) states that "there are a small number of organizations that provide structured professional development around DDDM….An untapped option, is to look to schools of education to help train current and future educators in data skills and knowledge" (p. 77).

We were interested in developing such opportunities for teachers and administrators within our own state. Though duration and coherence in professional development has been demonstrated to impact the depth of understanding (Shields *et al.*, 1998; Hiebert, 1999), professional development often consists of a one-time meeting where participants sit and gather information from an expert in the field (McLeskey and Waldron, 2002; Desimone, 2009). Teachers are then asked to take their new knowledge and incorporate it into their teaching (McLeskey and Waldron, 2002). However, this is not effective for changing teaching practices (Joyce and Showers, 2002; Borko, 2004; CAL, 2010; Smith, 2010; Wei *et al*., 2010; Stewart 2014). In contrast, "active learning that allows for teachers to focus on specific needs within their classroom has been found to improve teaching practices" (Stewart, 2014, p. 31). Active learning also requires teachers to work together in teams and learn from each other. Such collaboration enhances the coherence of training in ways that have shown to produce results (Garet *et al.,* 2001). Kekahio and Baker (2013) suggest that by building data teams in a school organization, the teams can "monitor student and school performance and efforts to improve performance within the organization. Data teams also have primary responsibility for organizing, analyzing, and coordinating data-informed responses" (p. 1). Building on the importance of active learning and data teams, we designed our data literacy training sessions to include teams of teachers and administrators from each school working collaboratively to use data to inform decision making at the classroom, school and district levels.

We explain the process of developing professional development by first describing the state and regional contexts in which we are working. We continue by explaining how we formed our university instructional leadership team and the K-12 teacher and leader teams. We then describe the data literacy training sessions and lessons gleaned from formal and informal evaluation instruments.

3. Context

Our state is one of many states in the United States that has adopted the CCSS. The state adopted the standards in 2011 and implemented them in 2013-2014. In order to measure how students are

meeting the new standards, the state joined 21 other states in 2013 to develop assessments with the Smarter Balanced Assessment Consortium (SBAC) (OPI, 2015). This consortium was formed to develop and implement assessments that measure student progress toward college and career readiness. The SBAC assessment is a computer adaptive, summative assessment in which each student's test is customized based on his or her performance throughout the test. Districts within our state are required to use these SBAC data to determine students' proficiency levels in math and ELA aligned with the CCSS. In addition, districts are supposed to use these data to inform efforts on how to increase student achievement across all demographics. However, little information or opportunity presently exists that would enable teachers to learn how to better understand their students' performance data in relation to the new SBAC goals and assessments, let alone on how to use these data to inform and improve instruction. Deepening educators' understanding of the benefits of analyzing data and using the results to improve instructional practices creates the necessary momentum to successfully implement the CCSS as an agent to increase students' academic achievement.

Recognizing this need, faculty in a department of education at a land-grant institution located in the northwest United States partnered with a regional superintendent consortium to discuss how university faculty could better assist teachers and administrators in developing data literacy skills. Faculty from the department of education included professors from Educational Leadership and Curriculum and Instruction. Three collaborative meetings were held so that both faculty and superintendents could discuss the needs (student, teacher, administrative, community) of regional K-12 school districts. Areas of need specifically identified by superintendents included data collection, data analysis and using data for instructional and programmatic improvement. As a result of these collaborative discussions, it was determined that university faculty would join with local school districts to provide professional development opportunities in data literacy.

3.1 University Instructional Leadership Team

When forming the university instructional leadership team, we identified individuals with a broad range of expertise in order to create a team diverse in background and experience. For example, one of the researchers spent 30 years working as a teacher and administrator before taking a faculty position guiding future principals and superintendents. Another researcher with over 15 years of experience teaching grades K-12 is now faculty and instructs pre-service and graduate students with a specialization in classroom assessment. A third researcher joined the team based on her passion for statistics. She is a faculty member who teaches research methods and statistics courses for education students. The fourth researcher is a statistics faculty member with experience developing statistics courses for practicing teachers. Our final researcher was a doctoral student who has experience teaching elementary students. He is now faculty in a teacher preparation program at a rural university in a neighboring state.

Once our team was formed, we made professional training opportunities available to teams of teachers and administrators. These opportunities included three half-day seminars during the academic spring semester and a summer course. Although participants were encouraged to enroll in school-based teams of teachers and leaders, it was not a requirement for seminar attendance. As an added incentive, seminar participants were guaranteed enrollment in the summer graduate-level course designed as a follow-up to the data literacy seminars.

The training was designed to address the following goals: (1) Understand and use statistics to analyze classroom and district data in school-based teams; (2) Develop collective expertise in data literacy so the school-based teams can work together to practice new skills and eventually train other educators at their schools; (3) Share expertise across schools and provide a network of support once school-based teams return to schools; (4) Provide undergraduate students with opportunities to interact with and learn from teacher participants; (5) Encourage continued participation in data literacy training through graduate coursework. Ultimately we hoped these goals would initiate a culture of data literacy and DDDM in school settings. In the next section, we describe our efforts to achieve these goals by discussing the design and implementation of professional development opportunities in data literacy and DDDM. Although a summer graduate course was also part of this overall design, this paper focuses primarily on the spring seminars.

4. Program Implementation

4.1 Spring Seminar Participants

The spring seminars had 16 participants (15 teachers, 1 superintendent). Three of the participants were male and 13 were female. All of the participants were Caucasian and from schools with fewer than 250 enrolled students. On average the participants were 34.4 (*SD*=5.61) years-old and had 6.7 (*SD*=3.46) years of teaching experience. Nine of the participants had a bachelor's degree and seven had a master's degree.

4.2 Seminar Overview

We designed three half-day seminars to help teams of teachers and administrators work together to execute a plan to make school-wide data analysis an ongoing, collaborative process rather than a stand-alone event. Each seminar had approximately three hours of activities, discussions and instruction focused on the following topics: 1) data collection and use, 2) data organization and summary at the classroom level and 3) data interpretation and question posing at both the classroom and the school-wide levels. During the seminars, we used several small group activities in order to model the data inquiry process and facilitate school team building and expertise in data literacy. In addition, we had school-based teams share their specific practices with the larger group in order to expand everyone's knowledge of assessment and collection processes. This instructional approach proved valuable not only in school team building, but also in expanding participants' awareness of other possible assessment and data collection systems.

The series of three-hour seminars were intentionally scheduled one month apart so the teams could return to their respective schools and share what they had learned with their colleagues. This spacing also allowed school-based teams to bring back questions and observations to discuss with the rest of the teams at the next seminar. In addition, we had time to design seminar activities that directly responded to the participants' needs and concerns that were noted on the end-of-seminar evaluation forms.

In the following sections, we describe each of these three seminars in detail. For each seminar, we begin by identifying the overall goals and topics discussed, and then we highlight key activities and

observations. Because we wanted the seminars to be responsive to the participants' needs, these observations were instrumental in the design of subsequent seminar activities.

Seminar I: The first three-hour seminar was offered in March 2014, and even though it focused on topics concerning data collection and use, there were several secondary goals. We wanted to familiarize ourselves with how the participants had previously used data. We also wanted to build a sense of community among the school-based teams of teachers and administrators. Furthermore, we wanted the participants to engage in meaningful conversations with pre-service teachers in order to establish connections and enhance their professional growth. In general, this first seminar was meant to build rapport with one another and establish a framework for the rest of the seminars.

In order to meet these goals, we used several team activities and open-ended discussions focused on these three main learning outcomes:

(1) Identify multiple data sources and how they can be used to improve instruction;
(2) Explore how to analyze and interpret data in ways that help inform instruction; and
(3) Articulate how your school data team can support teachers' use of data to improve instruction.

Our first activity was designed to address the first learning outcome which was to help teachers identify multiple data sources and their uses for improving instruction. Using an adapted version of the "The Data Pyramid" activity from Success at the Core Facilitator's Guide (2010), each school team identified the types of formative and summative assessments they were currently using and how they were using the data from those assessments. They also discussed what additional types of data they would like to use and how they would use that data in their schools. After each team discussed this topic, participants shared their responses with other schools. This allowed teams to compare the different types of data various schools collect and brainstorm new ways their data could be used. For example, several of the schools were using benchmark assessments to place students in leveled reading groups (or flexible ability groups) at the beginning of each school year. Through a more focused discussion, teams realized that if analyzed soon enough, the benchmark assessments could be used to focus instruction more specifically on skills student have not yet mastered. In addition, several school-based teams discovered the potential for understanding school climate by collecting data from parent/guardian surveys.

The next activity included two different parts, each meant to address the second learning outcome by giving teams the opportunity to analyze and interpret data. For the first part of the activity, each team received data sets with students' fictitious math and reading scores. Then the teams discussed how they could use the data to learn about classroom-level and student-level performance and what that kind of information reveals about classroom instruction. During this activity, we observed that several teams analyzed the data on an individual student basis, but not on a classroom-level basis. Consequently, they were able to make statements about changes in individual student scores, but were not able to look at the groups holistically in order to make statements about overall instructional effectiveness. This was an important point for us going forward, as we realized that we needed to also focus on classroom- and grade-level analyses.

Because this seminar was held on the college campus, we were able to coordinate the seminar with an undergraduate Assessment in Education class so that the 40 students could participate in the second part of the data analysis and interpretation activity. We structured the activity so that the participating teachers could serve as "data experts," giving them valuable practice for discussing assessments and adapting instruction with colleagues in their own schools. Within small groups with approximately two participating teachers and four undergraduate students (pre-service teachers) each, the participating teachers led discussions about the kinds of assessments they administer and how they use the resulting data. Through these discussions, the pre-service teachers were able to ask questions and learn more about different schools' expectations for giving assessments and using performance data. Overall, the activity was well received by both participating and pre-service teachers, prompting us to design similar interactive activities for future seminars.

For the final activity, teachers watched the "Data Walls" video (Success at the Core, 2012b) that presented one example of how school data teams can support teachers' use of data to improve instruction. This led to a rich conversation about the challenges teachers face when using student data to make instructional decisions and what supports would be most valuable for them to do that successfully. For example, participants discussed how to display and store student data to keep accessibility without compromising confidentiality, how to create and use a data wall given the time constraints teachers currently face, and how to identify which data (and how much) to even include on a data wall. The discussion, coupled with the end-of-seminar evaluation, provided us with valuable feedback about the overall success of the seminar and ideas and directions for future seminars.

As homework, each school-based team was instructed to try a new strategy they had learned and share it with others at their school. With a month between each seminar, the teams had enough time to complete the assignment and formulate questions about implementing the strategy. They also had ample time to locate a data set they could bring to the following seminar in April that would help them answer a self-identified question of interest. In this way, we ensured the seminars were directly applicable to each team's needs and contexts.

Seminar II: The second seminar was offered in April 2014 and focused on the stated needs and questions the participants had about data analysis after the first seminar. The primary goal for the second three-hour seminar was to help the teams evaluate student-level data. Based on earlier participant feedback, we structured this seminar to address various tools and strategies teachers could use to investigate classroom data in order to help them make instructional decisions. Each team was to bring student performance data from its school, so we planned activities and open-ended discussions that allowed them to investigate those data.

To begin, the second seminar opened with several interactive activities that allowed the teams to reflect on and share their previous classroom and school experiences. Although these activities were primarily meant to stimulate discussions about analyzing student-level data, they also served as ice-breakers and roadmaps to keep the seminar focused on the participants' needs and interests. For example, during one activity, participants wrote responses to the following prompts:

- What issues are you having with data?

- What is your greatest frustration with data collection/analysis/decision making?
- What would you like to know/do that you can't do now?
- What other resources might help you?

Working in groups based on grade levels (K-3, 3-5, 6-8 or 9-12), participants shared their responses and discussed the similarities and differences they noticed across the grade levels and/or schools. Through these discussions and interactions, the teams were able to share their strategies for analyzing and using data. In addition, the activities helped build an awareness of the challenges other schools and teachers face when using data. For example, some participants noted that they have limited access to student data, primarily due to the inadequacy of their school data retrieval systems. Many identified time constraints as a barrier to using data and collaborating with other colleagues.

After the groups identified and discussed the various challenges they face when using data, we introduced different tools and strategies teachers can use to investigate classroom data, beginning with data walls, which we discussed in seminar one. Data walls are physical locations where individual student data are recorded and tracked visually. The purpose of a data wall is to visualize and explore individual student performance, and the teams had several questions about the logistics associated with creating a data wall. For example, a data wall could be a folder with "pockets" to organize cards denoting each student's performance on mathematics tests throughout the year. The introductory video that had been presented at the end of the first seminar served as a launching point for a more detailed discussion about practical issues associated with the creation and use of data walls. Specifically, we used a sample model of a data wall to broadly discuss various topics: 1) strategies for maintaining student confidentiality, 2) ways to construct and organize a data wall, 3) data requirements, including how to identify useful assessments for tracking student progress and 4) disadvantages and limitations of data wall use. After this discussion, a pre-service teacher assessment class joined the seminar and brainstormed with the teams about how feasible it would be to implement this type of strategy in their own classrooms. Using their own student data, the teams started developing data walls to investigate student performance and then reported their discoveries, challenges and proposed intervention strategies to other teams. This gave participating teachers the opportunity to try the strategy with their own student data while also interacting and discussing student intervention strategies with the pre-service teachers.

Although the teachers were interested in the idea of data walls, most expressed concerns about their feasibility with respect to time and confidentiality issues. As an alternative, we presented other tools for managing and utilizing student data and information. These tools included Data Delve, rubrics, grade book highlighting, item analysis and student notebooks/folders (Montgomery County Public Schools Website, 2014). After introducing these different strategies, the teams reflected on whether any of the tools would help address the concerns they had written at the beginning of the seminar and, if so, how they would actually implement the strategies in order to study student performance and evaluate the effectiveness of interventions.

After discussing tools for classroom-level analyses, we used the "Data Carousels" video (Success at the Core, 2012a) to transition the focus from classroom-level analyses to school-level analyses. Briefly, we discussed how data carousels differed from data walls, as well as the advantages and disadvantages of each. Most teams were hesitant that such an approach would work in their own

schools due to the difficulty of coordinating a school-wide data night for teachers to explore graphs of student performance across grade levels. However, they recognized that this approach could help them better identify systematic school-wide interventions for improving student performance.

In order to experience the data carousel process, each team was assigned to bring graphical summaries of their student performance data to the next seminar. These summaries, along with their question(s) of interest, would then be presented in a data carousel to generate questions and observations from the rest of the participants.

Seminar III: The third seminar, which was offered in May 2014, took on a different flavor than the previous two. The previous seminars offered hands-on activities to introduce teachers to various tools and data analysis strategies. However, the last seminar was designed to help participants apply these strategies to their own data and develop habits of inquiry for examining data across various levels (student, classroom and school-wide).

At the beginning of the seminar, school-based teams traded non-identifiable vertically articulated school level data with other teams so that participants would have the opportunity to examine data that was unfamiliar to them. A question was posed about each data set. With colleagues from other schools, participants observed each set of data and wrote observations and recommendations to answer the initial questions posed regarding each set of data. Groups then returned to their original data sets to view the recommendations that other teams had written.

The purpose of this activity was to immerse participants in the process of shared inquiry as they viewed data unfamiliar to them. We wanted to observe how they approached data analysis and incorporated strategies learned in previous seminars. It was also important to move teachers beyond the individual student level of analysis to the classroom and school levels of analysis. From our observations during the previous seminars, we saw that teachers generally had a good concept of their own students' performance, but were more disconnected from looking at grade-level or school-level performance. Furthermore, teachers did not look at data longitudinally by considering past performance in previous grades. From these indicators we understood that we had to provide activities that encouraged teams to begin thinking about grade-level and school-level data. A second goal of this activity was to give participants practice leading data analysis discussions so that upon returning to their respective schools, they would be more confident in leading similar professional learning opportunities.

Another goal for the third seminar was to discuss the DDDM process from a systems level, whereby school-based teams considered all of the components necessary to establish a culture of data literacy in their schools. At this point, we discussed the necessity of approaching school-level DDDM from a 30,000 foot view. Using *Leading Schools in a Data Rich World* (Earl and Katz, 2009), we discussed the importance of several concepts including: valuing deep understanding and not rushing to judgment, tolerating ambiguity and learning to ask the right questions or seeking the root cause. We wanted school-based teams to review their present DDDM model in light of Earl and Katz' recommendations and what they had learned during the spring seminars so that they would be able to recommend changes in their school policies or practices if necessary. Finally, we focused on how teachers would return to their schools and continue to champion ongoing data analysis as well as promote data literacy for more colleagues.

4.3 Summer Graduate Course

In addition to the data seminars, we designed a two-credit hour graduate course for participating teachers. The course, *Data Literacy for Teachers*, was designed to cover data collection and analysis tools commonly used to understand student performance in K-12 classrooms. Moreover, the aim was to provide exposure to basic statistical concepts such as descriptive statistics, graphs, correlation, t-tests and regression. Participating teachers studied the appropriate uses of statistical concepts and methods for answering educational inquiries about K-12 classroom and school practices. An important goal of this course was to provide opportunities for critical discussion of data collection and analysis in the K-12 environment with school-based teams and professional learning communities. For a copy of the course syllabus, please contact one of the authors.

4.4 Summer Graduate Course Participants

For the summer graduate course, there were 30 participants, and all of them were teachers (18 elementary, 13 middle school and 3 high school). Three of the participants were male and 27 were female. On average participants were 40 (*SD*=9.8) years-old with 11.1 (*SD*=8.19) years of teaching experience. All participants were from communities of fewer than 10,000 people. Please note, half of the participants in the summer course had participated in the spring seminars as well.

5. Evaluation

To evaluate the professional development opportunities, we used both formative assessment and survey data. The formative assessment data helped us to continually evaluate the seminars and revise their content and structure to best address participants' self-identified needs and concerns. The survey data, which was collected at three different time points (pre-seminar, pre-course and post-course), helped us investigate whether there were detectable changes in participants' sense of efficacy for DDDM and/or their DDDM anxiety.

5.1 Formative Assessments

We used an active learning strategy called 3-2-1 as a formative instrument to determine what teachers learned during each of the three data literacy seminars. The 3-2-1 strategy helps structure participants' responses to an activity, a reading, a film, or a combination of these. After participants engaged in the seminar content and activities, we asked them to answer the following questions:

- What are **3** things you learned about data literacy today?
- What are **2** things you need to know more about?
- What is **1** action you will take, regarding data, when you begin teaching?

The 3-2-1 assessment provides a quick way for presenters to check for understanding and to gauge participants' interest in and mastery of a topic. Sharing 3-2-1 responses can also be an effective way to prompt a class discussion or to review material from a previous lesson. In this research, the 3-2-1 tool was helpful for determining what was learned as well as what was not understood, and for informing future seminar and course content.

After each seminar, we read the participants' responses and identified recurring comments that emerged from the data collected. In the following sections, we summarize the major sets of comments we received and discuss how we used this information to plan the content and structure of subsequent seminars.

Post Seminar I Feedback: As we collected and analyzed the 3-2-1 formative assessment responses, three main sets of recurring comments emerged that helped our data team to revise and plan for the second seminar. The first set of comments identified that teachers wanted to know more about how to collect and organize data in ways that allowed more focused, in-depth analysis of individual classroom and school-wide data. In discussion, teachers stated that they had several sources of data to use for analysis, but they had difficulty organizing the data in a useful way that made decision-making easier. The second set of comments centered on a larger and somewhat ambiguous question of how to analyze the data in general. This feedback was non-specific and made us wonder if teachers wanted to learn certain statistical processes or whether they wanted guidance and reassurance on their current methods of data analysis. The third set of comments revealed teachers' desire to learn more about how to use data to inform instruction and/or implement programmatic changes. Specifically, teachers wrote about wanting to learn how they could know whether a particular program or instructional approach was working optimally with their students, or whether another program or a different instructional strategy might yield better results.

After analyzing the feedback from Seminar I, we planned our second seminar around the three specific needs that emerged in the 3-2-1 assessment. In Seminar II, we emphasized strategies that teachers could use to better organize data. We walked teachers through an activity that taught them how to use data walls as a means of organizing individual student and classroom data to track student progress against specific instructional approaches. In terms of the second set of comments, "how to analyze data," we decided to emphasize having teachers review and analyze data collaboratively in school or district teams so that they could discuss similarities and differences across grades. The collaborative analysis approach also worked well for addressing the third set of comments, which centered on "using data to inform instruction." Working collaboratively, participants were able to look more deeply at data and the implications for instruction. Having teacher teams look at all of the student data available increased the likelihood that specific performance issues would be discovered and could then be mitigated with the development of collaborative instructional plans for individual classroom and school-wide application. We also shared other strategies, such as Data Delve, grade book highlighting, rubrics and item analysis, for managing and utilizing student data and information.

Post Seminar II Feedback: The three main sets of recurring comments that emerged from the 3-2-1 formative assessment data for Seminar II were very similar to those identified after the first seminar. Following the Seminar II discussion about organizing classroom data and using it to inform instructional practice, teachers asked to learn more methods for effectively gathering, charting and tracking individual and group data both horizontally within a single grade or subject area and vertically across grades. Another general set of comments that emerged again from the 3-2-1 formative assessment was "how to use data for instructional improvement." However, this time some comments led us to speculate that what teachers were asking for was a guide for when (or at what point) they should discontinue a specific instructional approach in favor of adopting a new approach or keep the same instructional approach but seek out different resources. The last set of

comments addressed teachers' desire to learn new teaching strategies and interventions they could use when students did not make adequate progress or meet individual goals. This set of comments was not directly related to data literacy, but was more related to the need for teachers to broaden their teaching repertoire and find more resources they could use with greater success for struggling students.

The feedback from Seminar II aligned with one of our initial goals: to develop "in-house" expertise through the use of school or district–wide data teams. Therefore, for the third seminar we designed activities that required participants to work in teams analyzing data that was unfamiliar to them. Each team reviewed several sources of data, looking for evidence that illustrated students' mastery of content or discrepancies between content mastery and students' actual performance. Following an in-depth analysis of the data and discussions about areas of strength or weakness, each team cited evidence of student performance and gave recommendations to other teams. Some recommendations called for more data to be collected to confirm or disconfirm instructional hypotheses. Other recommendations specifically suggested using alternative curricular resources, changing instructional approaches, or re-grouping students by specific needs.

Post Seminar III Feedback: We used the 3-2-1 formative assessments from Seminar III to help us determine how successful the seminars were in terms of meeting our project goals; we also used these data to help us plan our summer data literacy class which was meant to be an extension of the spring seminars. The feedback teacher participants gave us after the last seminar revealed four distinct sets of recurring comments. The first set of comments centered on how to continue to use data to improve instruction. Although we had presented teachers with a few examples and strategies about how they might use data to inform instruction, there was still a desire to, in one participant's words, "find the silver bullet that will fix the problem." The second set of comments brought forth the idea that teachers wanted to know about and use different kinds of data other than the student assessment and achievement scores they had immediately available. For example, some teachers wrote that they wanted to learn how to explore whether relationships exist between different student demographic and achievement data. A third set of comments indicated that teachers saw the value in reading, using and interpreting graphs, and they wanted to learn how to create visual displays that would make data easier to understand. The fourth set of comments was closely related to this; teachers asked to learn how to more accurately describe the data, as well as present and summarize findings for parents and others in ways that are accessible.

Following the final seminar, our research team re-examined the feedback from all of the 3-2-1 formative assessments collected during the three seminars. Because some of the comments (e.g., "how to analyze data," "how to use data to inform instruction") were repeated across the seminars, we connected and built on all the feedback we received to plan the content and instructional activities for our summer course. During the course, we continued to address two primary goals: (1) Understand and use statistics to analyze classroom and district data in school-based teams; and (2) Develop collective expertise in data literacy so the school-based teams can work together to practice new skills and eventually train other educators at their schools. The content of our summer data literacy course focused on five specific areas/activities:

(1) *Data organization and visualization* – We taught teachers how to use EXCEL to organize data, obtain simple descriptive statistics, and display data in charts and graphs in order to

make data more accessible and easier to analyze. The visual representations also made it easier for teachers to discuss student performance with parents and others, as well as make cross-sectional and longitudinal comparisons.

(2) *Data analysis* – We reviewed basic data literacy terminology and concepts and also introduced some statistical tools (correlation, t-tests) teachers could use with sets of classroom or grade level/school data.

(3) *Research* – We introduced ways teachers could engage in action research to try out various instructional approaches and determine which strategies worked and which did not. We also exposed teachers to examples of educational research in order to help them better understand how they could use research to make decisions about instruction or specific programs.

(4) *Data driven decision making* – We created data sets that required teachers to analyze various kinds of classroom and grade level/subject area data. Following analyses and discussions, teachers cited evidence about performance and made recommendations for improvement based on the evidence they cited.

(5) *Team/Collaborative approach* – Throughout the summer course, we emphasized the goal of creating a culture of data literacy in their schools, and that decisions are best made by teams/groups where several different perspectives enhance the overall quality of analysis and expand the possibility of solutions based thinking. Every activity we offered had a collaborative component that reinforced the development of school team expertise.

5.2 Survey Data

The DDDM efficacy and anxiety (3D-MEA) inventory (Dunn *et al.*, 2013) is an instrument that was developed and validated for use with K-12 teachers who have diverse experiences in DDDM. Using a five-point Likert scale ranging from 1 to 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree), this 20-item instrument measures teacher DDDM efficacy and anxiety at the classroom level. Within this context, "teachers' sense of efficacy for DDDM [is] defined as teachers' beliefs in their abilities to organize and execute the necessary courses of action to successfully engage in classroom-level DDDM to enhance student performance" (Dunn *et al.*, 2013, p. 88), and "DDDM anxiety is the trepidation, tension, and apprehension teachers feel related to their ability to successfully engage in DDDM" (Dunn *et al.*, 2013, p. 87).

The 3D-MEA inventory has five reported subscales: 1) Identification – efficacy for data identification and access; 2) Technology – efficacy for data technology use; 3) Interpretation – efficacy for data analysis and interpretation; 4) Application – efficacy for application of data to instruction; and 5) Anxiety – DDDM anxiety. The scales have reported reliabilities ranging from .81 for the Interpretation scale to .92 for the Application scale, and the results of a confirmatory factor analysis indicate evidence of convergent validity. Researchers and others may use the entire instrument, or a subset of the scales, to investigate how teacher DDDM efficacy and anxiety evolves, particularly within the context of DDDM professional development.

We administered this 20-item instrument via Survey Monkey to all participants while they were on-site for professional development. The survey data was collected at three different time points: 1) Pre-Seminar – prior to the start of the spring seminars; 2) Pre-Course – prior to the start of the summer course, but after the completion of the spring seminars; and 3) Post-Course – after the

completion of the summer course. We collected these data to help us investigate whether there were detectable changes in participants' DDDM efficacy and/or their DDDM anxiety.

Due to the limited number of participants, we were not able to use a confirmatory factor analysis to calculate the participants' subscale scores. Instead, we used a participant's mean response to items on a given subscale. Therefore, at a given measurement occasion, a participant has up to five different subscale scores, one for each of the five previously identified subscales. Through this approach, all items on a given subscale are weighted equally and participants' subscale scores represent their mean responses to the items on that subscale.

At each of the measurement occasion, we used descriptive statistics to immediately summarize the data and interpret the findings. After the third measurement occasion, we used linear mixed models for repeated measures in SAS® software[1], Version 9.4, to estimate changes in participants' Identification, Technology, Interpretation, Application, and Anxiety subscale scores across time. We allowed repeated measurements on the same participant to co-vary by specifying an unstructured variance-covariance error structure. In addition, we used the Kenward-Roger adjustment for degrees of freedom and conducted post-hoc analyses using the "CONTRAST" statement in SAS software to investigate the differences between the measurement occasions of interest. In the following sections, we summarize the results of each of these analyses and discuss what these findings tell us about the seminars and course.

Descriptive Statistics: In order to investigate the spring seminar participants' DDDM efficacy and DDDM anxiety in a timely manner, we summarized participants' subscale scores using means and standard deviations after each measurement occasion (see Table 1) and compared the results to our own observations and participants' 3-2-1 feedback. For example, prior to the seminars, the survey data suggested that participants had neutral to positive subscale scores on average (see Table 1). Our interactions with participants during Seminar I reinforced these survey data results; a majority of the participants noted that they access to lots of student data, and some even commented on using the data to track individual student learning. In general, the participants saw the value in using data to make instructional decisions and communicated a sincere interest in learning how to use data to inform decision making at the classroom and school district levels.

Table 1 Descriptive statistics (means and standard deviations) for spring seminar participants' subscale scores across the three measurement occasions

	Pre-Seminar (n=15)		Pre-Course (n=11)		Post-Course (n=10)	
Scale	M	SD	M	SD	M	SD
Identification (3 items)	3.51	1.01	3.39	0.53	3.80	0.65
Technology (3 items)	3.40	1.00	3.09	0.86	3.73	0.80
Interpretation (3 items)	3.77	0.56	3.67	0.39	4.13	0.39
Application (6 items)	3.65	0.58	3.67	0.46	4.10	0.52
Anxiety (5 items)	2.66	1.12	2.80	0.66	2.27	0.79

[1] *SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc. in the USA and other countries. ® indicates USA registration.*

Prior to the start of the summer course, we observed that spring seminar participants had mean subscale scores that were closer to neutral (see Table 1). Even though this may have resulted from attrition, the findings did not surprise us due to our goals for the seminars and the feedback we had received from the 3-2-1 assessment. We designed the seminars to provide teams of teachers and administrators with the resources they needed to make school-wide data analysis an ongoing, collaborative process. The seminars focused on sharing and/or demonstrating different tools and strategies the school-based teams could use to support their data analysis efforts; they did not cover the mechanics of organizing, analyzing and interpreting various types of data. Given that the 3D-MEA instrument is comprised of several items that assess teachers' self-efficacy and confidence to complete certain data-related tasks and the participants consistently noted that they wanted to learn "how to analyze data" and "how to use data to inform instruction" on their 3-2-1 assessments, we concluded that the participants' "neutral" mean subscale scores reinforced the need for our summer data literacy course to focus on the content areas we had identified after the Seminar III.

Repeated Measures Analysis: After the completion of the summer data literacy course, we examined longitudinal changes in the spring seminar participants' subscale scores. Because of attrition, we examined these changes using least-squares means. As illustrated in Fig. 1 and reported in Table 2, there were no meaningful changes in mean subscale scores over the duration of the seminars for each of the five subscales on the 3D-MEA inventory. However, there is moderate to strong evidence that over the duration of the course, participants' subscale scores increased, on average, for three of the subscales: (1) Technology (95% CI: 0.53 ± 0.38, $F(1, 9.03) = 10.20$, $p = .011$); (2) Interpretation (95% CI: 0.44 ± 0.29, $F(1, 9.63) = 12.02$, $p = .006$); and (3) Application (95% CI: 0.42 ± 0.41, $F(1, 9.34) = 5.31$, $p = .046$). In addition, their Anxiety subscale scores significantly decreased on average (95% CI: 0.47 ± 0.35, $F(1, 9.76) = 9.17$, $p=.013$). This, coupled with the fact we observed similar changes in mean subscale scores for other course participants who did not complete the spring seminars, provides promising evidence that participants' DDDM efficacy and DDDM anxiety improved over the duration of the data literacy course.

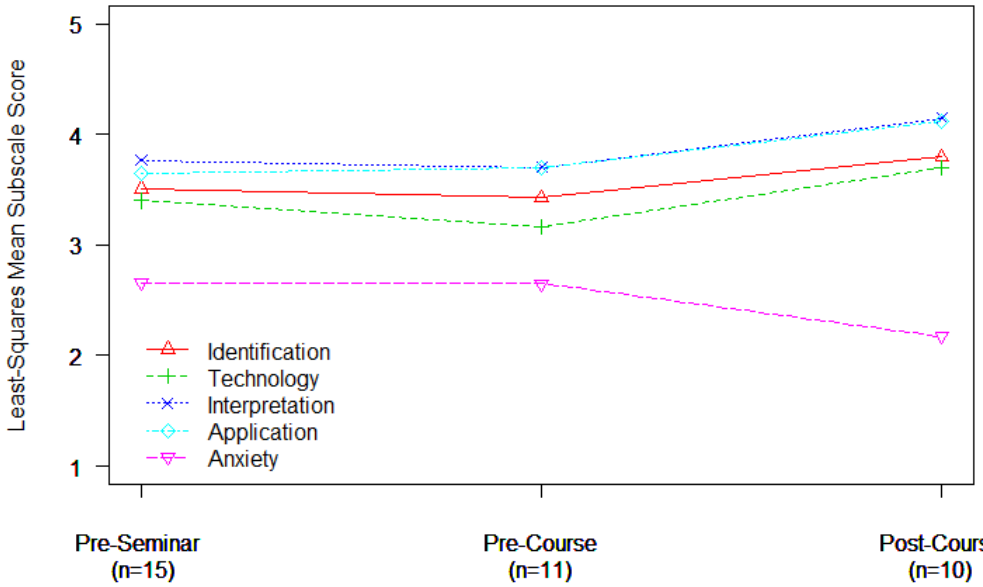

Fig. 1. Spring seminar participants' least-squares mean subscale scores for each of the five subscales on the 3D-MEA inventory across the three measurement occasions

Table 2 Least-squares mean differences in subscale scores across measurement occasions for spring seminar participants

	Pre-Course – Pre-Seminar			Post-Course – Pre-Course		
Scale	Est	SE	p-value	Est	SE	p-value
Identification	-0.09	0.21	.686	0.37	0.22	.129
Technology	-0.23	0.31	.461	0.53	0.17	.011
Interpretation	-0.06	0.16	.706	0.44	0.13	.006
Application	0.05	0.17	.778	0.42	0.18	.046
Anxiety	-0.01	0.15	.965	-0.47	0.16	.013

6. Discussion and Conclusion

Reflecting on our experiences, our professional development activities provide potential for future training in data literacy. Teachers realize that they lack knowledge and practice in using data to improve student outcomes. For example, one participant said, “Learning to interpret data correctly was all new to me.” Another participant noted, “I am terrified with anything to do with higher level math, however after this class I plan to really use the data I collect on my students every year.”

Our experiences highlight the importance of incorporating a team approach when designing professional development. Our incorporation of teams was twofold. First, the diversity of the university instructional leadership team fostered professional development through the sharing of distinct expertise and skills with participants. Equally important, we found the school-based team approach to be effective. A participant noted, “I am hopeful to be able to help my colleagues and administration understand some of our data and how it can be used to our benefit.” Many of the participants commented on how they will disseminate information with colleagues not attending the trainings. Although we had limited participation from school-based teams, the team in which the superintendent participated in the seminars knew they had administrative support for instilling the ideas presented, thus reinforcing the importance of administration's involvement in successfully creating a culture of DDDM.

Throughout this entire process, we recognized the importance of remaining flexible. Prior to offering the seminars, we had used results from a needs-based assessment completed by superintendents to identify topics for each seminar. In the survey, superintendents identified data literacy topics in which teachers and leaders needed professional development and support. However, after the first seminar was offered, we soon recognized we needed to adapt our initial plans to more fully address teachers’ and administrators’ stated needs. By continuously seeking participant input via open discussions and end-of-seminar evaluation forms, we were able to adapt seminar topics and activities on an ongoing basis. This flexibility and open communication allowed us to design materials and activities that were responsive to their needs, creating an open environment in which they knew their feedback was valued.

The professional development opportunities were appreciated by several rural teachers. Many participants were from small schools, where there was only one teacher per grade level. Therefore, participants benefited from the opportunity to talk to other professionals teaching similar grades and subject areas. The collaboration also fostered a greater awareness of other kinds of

assessments that might be useful to them in their classrooms. Moreover, the seminars provided time and opportunity that was missing from their daily schedules to explore how they can use data to inform their decision making.

The participating teachers and pre-service teachers also benefited from their interactions with one another. The pre-service teachers got to hear firsthand how teachers in the field create and use assessments. A pre-service teacher commented that it is important to see how current educators handle data information. Moreover, they noted the importance of "being cooperative and willing to communicate with co-workers; [and] develop[ing] a good relationship with other educators within my school." In addition, the participating teachers got to share their practices and serve as "data experts." By discussing data with the undergraduate teacher candidates, the participating teachers gained experience with how they would lead similar discussions about data use when they returned to their schools.

Based on our experiences, there are several changes we advise making for future data literacy training opportunities. First of all, in order to effectively implement a school-based team approach, we learned it is essential to obtain firm commitments from school leadership to participate. Prior to the data literacy training, administrators supported our efforts noting that data literacy is a great area of need. However, only one administrator attended all three seminars; the other school-based teams were comprised solely of teachers, with as few as one teacher from a single school, to as many as nine. By committing to participate, administrators can be actively involved in creating a culture of DDDM within their districts and schools.

In addition, school-based teams should commit to the entire data literacy training experience. Due to miscommunication, scheduling conflicts and a variety of other reasons, only a few teams attended all three seminars and the subsequent summer graduate course. Because of the limited time available and the sequential nature of the training topics, these teams received a different experience than those who could only attend a subset of the training opportunities provided. This was particularly true for the summer graduate course we offered. Many of the teachers that participated in the seminars also completed the subsequent summer graduate course, but there were several other teachers enrolled in the course who had not completed the seminars. These differing backgrounds limited the amount and depth of topics we were able to discuss, because only 50% of the teachers were familiar with our references to previous seminar topics and conversations. Similarly, seminar participants who did not complete the summer graduate course missed the opportunity to enrich their data management and data summary skills, as well as their understanding of key terminology. A few participants commented that they wished the course had come before the seminars, because they did not have a strong background in how to summarize data, limiting their ability to apply the information from the seminars. This may have also been true for seminar participants who did not take the resulting course, limiting the potential effectiveness of the training experience.

Finally, we recommend incorporating more opportunities for participating teachers to interact with pre-service teachers. Even though only two of the three seminars had activities designed for this type of involvement, the interactions between participating teachers and undergraduate teacher candidates were well received and proved beneficial for all involved. These types of opportunities can help strengthen ties between participating teachers and pre-service teachers, thereby

continuing to strengthen and promote a culture of data literacy and DDDM across the teaching spectrum.

In summary, the purpose of our research was to examine a process of how school districts could develop a culture of data literacy and DDDM by implementing professional development training for teachers and administrators. Understanding the need for training in data literacy and DDDM, we suggest there is a need for professional development that is authentic and incorporates a team approach. Our insights provide important direction for university faculty and school district administration as they seek to develop partnerships where university providers design professional development and outreach opportunities that support student learning.

Acknowledgements

This work was supported by the Office of the Montana Commissioner of Higher Education/Pass through from the U.S. Department of Education under Federal Grant CFDA Number 84.367 Title II Part A –Improving Teacher Quality. All findings and opinions are those of the authors and not necessarily of the Office of the Montana Commissioner of Higher Education or the U.S. Department of Education.

Conflict of Interest

None

References

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. Educational Researcher, 33(8), 3-15. http://dx.doi.org/10.3102/0013189X033008003

Center for Applied Linguistics (2010). Framework for quality professional development for practitioners working with adult English language learners

Creighton, T. (2006). Schools and data: The educator's guide for using data to improve decision making. Thousand Oaks, CA: Corwin Press.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualization and measures. Educational Researcher, 38(3), 181-199. http://dx.doi.org/10.3102/0013189X08331140

Dunn, K., Airola, K., Lo, W., & Garrison, M. (2013). What teachers think about what they can do with data: Development and validation of the data driven decision-making efficacy and anxiety inventory. Contemporary Educational Psychology, 38(1), 87-98. http://dx.doi.org/10.1016/j.cedpsych.2012.11.002

Earl, L. M., & Katz, S. (2009). Leading schools in a data rich world. Thousand Oaks, CA: Corwin Press.

Garet, M. S., et al. (2001). What makes professional development effective? Results from a national sample of teachers. American Educational Research Journal, 38(4), 915-945. http://dx.doi.org/10.3102/00028312038004915

Hiebert, J. (1999). Relationships between research and the NCTM standards. Journal for Research in Mathematics Education, 30(1), 3-19. http://dx.doi.org/10.2307/749627

Joyce, B., & Showers, B. (2002). Student achievement through staff development. Alexandria, VA: Association for Supervision and Curriculum Development.

Kekahio, W., & Baker, M. (2013). Five steps for structuring data-informed conversations and action in education (REL 2013–001) Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Pacific.

Mandinach, E. B. (2012). A perfect time for data use: Using data-driven decision making to inform practice. Educational Psychologist, 47(2), 71–85. http://dx.doi.org/10.1080/00461520.2012.667064

Mandinach, E. B., & Gummer, E. S. (2013). A systemic view of implementing data literacy in educator preparation. Educational Researcher, 42(1), 30-37. http://dx.doi.org/10.3102/0013189X12459803

McLeskey, J., & Waldron, N. L. (2002). Professional development and inclusive schools: Reflections on effective practice. The Teacher Educator, 37(3), 159-172. http://dx.doi.org/10.1080/08878730209555291

Means, B., et al. (2011). Teachers' ability to use data to inform instruction: Challenges and supports. Washington, DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development.

Montgomery County Public Schools Website (2014).

Office of Public Instruction (2015).

Shields, P. M., Marsh, J. A., & Adelman, N. E. (1998). Evaluation of NSF's Statewide Systemic Initiatives (SSI) Program: The SSIs' impacts on classroom practice. Menlo Park, CA: SRI.

Success at the Core (2010). Facilitator Guide Success at the Core (2012a). Data Carousels Success at the Core (2012b). Data Walls

Smith, C. (2010). The great dilemma of improving teacher quality in adult learning and literacy. Adult Basic Education and Literacy Journal, 4(2) 67-74.

Stewart, C. (2014). Transforming Professional Development to Professional Learning. MPAEA Journal of Adult Education, 43(1).

Wei, R. C., Darling-Hammond, L., & Adamson, F. (2010). Professional development in the United States: Trends and challenges. Dallas, TX: National Staff Development Council.

U.S. Department of Education, Evaluation and Policy Development (2011). Teachers' ability to use data to inform instruction: Challenges and supports. Washington, D.C.: Office of Planning.