Teaching Data Analysis to Elementary Students with Mild Disabilities

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Abstract

The purpose of this manuscript is to describe the implementation of an action research project in a fifth grade resource classroom. Students with mild disabilities were taught how to conduct surveys using three data collection methods, display the data collected in tables and graphs, and use the data to answer survey questions.

Keywords

data analysis, mathematics instruction, data collection, surveys

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The six students in Mrs. Shupe's fifth grade mathematics group were working to meet Annual Yearly Progress (AYP) expectations identified by state standards. The state standards were aligned to AYP expectations stated in the No Child Left Behind Act of 2001 (NCLB). The students have been identified as having math disabilities and qualified for special education services using the Individuals with Disabilities Education Act of 2004 (IDEA) categories of learning disabilities and communication disordered. Of the six students, five had specific learning disabilities and one had a communication disorder.

The mathematics goals written in each student's Individualized Education Plan (IEP) were designed to provide each student access to the general education mathematics curriculum. According to school district policy, these students left their general education classroom on a daily basis for one hour to attend Mrs. Shupe's special education resource room for mathematics instruction. The students had been doing well with grade level expectations for the Data Analysis standard, so when a situation arose that required Mrs. Shupe to survey all of her resource students, she asked these students to help her plan and conduct the survey. She was surprised that even though these students were able to answer questions on the state core mathematics exam about data collection methods and displaying data in graphs and tables, they did not know how to formulate a question or plan how to collect the data using a survey approach. This gap between knowledge and application provided an ideal teaching opportunity that was aligned to the National Council of Teachers of Mathematics (NCTM) expectation for students to ***formulate questions that can be subsequently answered through data collection, organization, and visual display*** *(NCTM 2000; NCTM 2006).*

Empowering students to answer questions paves the way to informed decision-making and is the foundation of responsible citizenship.

Many students with disabilities struggle to apply mathematics knowledge to real-world situations. The NCTM expectation for data collection is included in the standards to develop and promote application of mathematics knowledge and skill to real-world situations. The data collection expectation goes beyond the traditional focus of teaching students to read and interpret tables and graphs, and adds an important dimension that prepares students to be collectors and consumers of research. Beginning in kindergarten, students are introduced to concepts of data and methods of data collection. In subsequent grades, these concepts become more complex and sophisticated. Empowering students, such as Mrs. Shupe's math students, to ask questions and collect data to answer questions paves the way to informed decision-making and is the foundation of responsible citizenship and consumer know-how. Based on years of research related to the effectiveness of explicit instructional approaches for teaching students with mathematics disabilities (Butler, Miller, Lee, & Pierce, 2001; Hudson & Miller, 2006; Kroesbergen & Van Luit, 2003; Maccini & Hughes, 1997; Mastropieri, Scruggs, & Shiah, 1991; Miller, Butler, & Lee, 1998), Mrs. Shupe, along with university researchers, designed seven phases that would help her students meet the NCTM expectation (Table 1).

Phase 1: Identify Instructional Goals and Objectives

The state data analysis standard was examined related to the NCTM expectation, and two main goals with related objectives were identified for each goal (see Table 2). Goals and objectives were limited to ensure opportunities for student mastery of the data analysis concepts while still preserving instructional time for other important mathematics standards (e.g., numbers and operations, measurement).

Phase 2: Select an Instructional Approach

Based on previous experience teaching these particular students and based on our knowledge of beneficial teaching approaches for students with disabilities, Mrs. Shupe decided to use an explicit or direct teaching approach. She believed this approach would likely result in success for her students.

Table 1: Seven Phase Instructional Approach

Phase 1: Identify Instructional Goals and Objectives
Phase 2: Select an Instructional Approach
Phase 3: Select a Data Investigation Strategy
Phase 4*:* Plan and Teach Students How to Conduct Surveys Using the Hand Raising Method (Objective 1a)
Phase 5: Plan and Teach Students How to Plan and Conduct Surveys Using a Ballot Method (Objective 1b)
Phase 6: Plan and Teach Students How to Conduct Surveys Using the Ballot Method and Unlimited Response Questions (Objective 1c)
Phase 7: Plan and Teach Students How to Develop Tables and Graphs to Display Survey Data (Goal 2)

Explicit instruction has been consistently validated as an effective approach for teaching mathematics to students with special needs (Kroesbergen & Van Luit, 2003; Swanson & Hoskyn, 2001). In the explicit or direct instruction approach, each lesson includes four stages: advance organizer, demonstration, guided practice, and independent practice (Miller & Hudson, 2007). In the first stage, the *advance organizer*, prerequisite knowledge is reviewed, essential vocabulary is pre-taught, the lesson objective is stated in "kid language," and students are helped to see the importance of the new lesson (Williams & Butterfield, 1992; Miller, 2002). Once the advance organizer is completed, the teacher moves to the *demonstration*. The demonstration consists of the teacher modeling the overt actions as well as decision-making to solve a problem or complete a task. The teacher engages students verbally with a high level of questions and prompts (Rosenshine, 1995). In the third stage, *guided practice*, the teacher provides students with opportunities to prac-

tice the problems. The teacher assists and supports students as they begin to apply the steps modeled by the teacher. Students are highly engaged, and the teacher uses students' verbal and written responses to monitor performance, and provide positive and corrective feedback. Once students complete problems accurately and without teacher assistance, the teacher moves to the *independent practice* stage of instruction where students solve problems independently. The explicit teaching sequence has been used successfully to teach all types of mathematics problems to students with disabilities.

Table 2: Goals and Objectives

Goal 1: Given questions requiring *limited and unlimited** responses, students will conduct investigations using hand raising and ballot survey methods, and summarize the results to answer the questions.

Objective a: Given a question requiring *limited* responses, students will conduct a survey using the hand raising method, and summarize the data to answer the question.

Objective b: Given a question requiring *limited* responses, students will conduct a survey using a ballot method and summarize the data to answer the question.

Objective c: Given a question requiring *unlimited** responses, students will conduct a survey using a ballot method and summarize the data to answer the question.

Goal 2: Given questions requiring limited responses, students will collect the data, summarize the results, and display the data in a table or bar graph to answer the question.

Objective a: Given a question and a limited response data set, students will display the data in a table.

Objective b: Given a question and a limited response data set, students will display the data in a bar graph.

* Students initially worked with survey questions that had limited or set answers for respondents to choose from, e.g., "Is pink or blue the favorite class color?" Later, students worked with survey questions with an unlimited or open-ended response format, e.g., "What is your favorite color?"

Phase 3: Select a Data Investigation Strategy

Mrs. Shupe and the university researchers selected a data investigation strategy (Hudson & Miller, 2006) that involved four strategy steps (see Figure 1). These strategy steps were selected for several reasons. First, they are appropriate for conducting surveys using a variety of data collection methods. Second, the four-step strategy can be easily adapted for a specific data collection method by adding sub-steps that guide students in the data collection process.

Phase 4: Plan and Teach Students How to Conduct Surveys Using the Hand Raising Method (Objective 1a)

The four-step data investigation strategy was adapted for the hand raising method with three sub-steps added under Step 2 (See *a*, *b*, and *c*). These sub-steps guided Mrs. Shupe's students in the collection of the data.

Step 1: Formulate the question.
Step 2: Plan and collect the data
(a) list choices
(b) call for a vote
(c) write a tally for each hand raised
Step 3: Count and write the totals
Step 4: Answer the question

Figure 1: Data Investigation Strategy

Step 1: Formulate the question

Step 2: Plan and collect the data

Step 3: Count and write the totals

Step 4: Answer the question

Only questions allowing for limited responses were used for the hand raising lessons. For example, if the question was "What is the favorite school lunch?" Mrs. Shupe helped students narrow the range of possible responses or choices to pizza, hamburgers, and hot dogs, and then reworded the question to be more specific: "Is pizza, hamburgers, or hot dogs the favorite school lunch? Limiting the choices helped students manage and organize the data as it was collected. Use of a data collection form also helped students during this phase of the instructional process (see Figure 2 in appendices).

The lesson began with an advance organizer. For the first hand raising lesson, Mrs. Shupe began the advance organizer by introducing the concepts of data and survey. This led to a discussion of when students might find it useful to collect data with a survey to answer certain kinds of questions. Students volunteered the types of survey questions they were curious about (e.g., What is the group's favorite winter sport?) and the type of data that would be collected (e.g., the name of the student's favorite winter sport). Mrs. Shupe then stated the objective for the lesson. After the first lesson, the advance organizer included reviewing the data investigation steps, and stating the lesson objective.

Following the advance organizer, Mrs. Shupe demonstrated each of the four data investigation steps and modeled how to formulate the question, plan and collect the data, count and write the totals on a data collection form, and answer the question. Once the demonstration was complete, Mrs. Shupe provided opportunities for guided practice related to the steps she had just demonstrated. Initially, Mrs. Shupe provided many prompting questions to ensure student success with the strategy steps, but gradually she shifted more and more responsibility to the students. For example, during step one, Mrs. Shupe and the students began by discussing what the question was and how to word it. At first, she wrote the question on the board and students copied, but as the students became more proficient with the process, they were expected to formulate and write their research questions independently. Similarly, for steps 2, 3, and 4, Mrs. Shupe initially provided prompts to facilitate students through the process, and then faded the prompts. It is important to note that each practice opportunity required a *new* research question, so that students had the opportunity to follow the process all the way through from beginning to end.

By independent practice, all students were able to complete all of the data investigation steps without teacher assistance. The configuration of the independent practice was unique. When a survey topic was proposed, all students independently formulated and wrote a question on a piece of paper (step 1), however, in step 2, only one student planned and conducted the survey: listing the choices, calling for the vote, and writing a tally for each hand raise. All students completed steps 3 and 4 by counting the tallies on the board from the vote, and then answering the question. Each new question practiced allowed another student to conduct step 2 independently. The reason the independent practice was configured this way was to maximize the engagement and practice of all students in the group for each new question. Six data investigations were conducted in this fashion with students' performance averaging 91% accuracy. The final application of the four data investigation steps occurred around Valentine's Day, and students worked in pairs to survey other instructional groups in the class as to their favorite Valentine's Day candy. Figure 3 (in appendices) shows the data collection sheet used for the Valentine's Day survey.

The performance of all students improved to an average of 90%.

Phase 5: Plan and Teach Students How to Conduct Surveys Using the Ballot Method (Objective 1b)

When students had mastered conducting surveys with the hand raising method, Mrs. Shupe decided students were ready to move on to the ballot method. Two ballot methods were taught. The first ballot method was similar to the hand raising method in that the questions had limited responses or choices and the method allowed for votes to be automatically sorted for totaling. One question used for the ballot survey was "Is blue, red, or green the favorite color of students in our class?" To collect the data in step 2, three substeps were added: (a) label a container for each choice, (b) provide each voter with an object for voting, and (c) take turns voting (see Figure 4 in appendices). The previously discussed lesson procedures (i.e., advance organizer, demonstration, guided practice, independent practice) were used to teach the first ballot method for surveying groups. Six data investigations were conducted at the independent practice level with students' performance averaging 92% accuracy

Phase 6: Plan and Teach Students How to Conduct Surveys Using the Ballot Method with Unlimited Response Questions (Objective 1c)

Following instruction and practice with the first ballot method, we adapted the four-step data investigation strategy for a second type of ballot survey. Table 3 shows the four data investigation steps with added substeps for steps 2 and 3. This ballot method required written responses from those being surveyed. Each written response was placed in a single container to be totaled. This method offers two advantages over the previous two survey methods. First, it provides a record of each person's vote, and second, this method is suitable for unlimited response questions. An unlimited response question is one that allows the person surveyed to respond with any possible choice related to the question. For example, with the question "What is your favorite cookie?" the person surveyed can answer with any type of cookie. However, totaling the votes (step 3) is more difficult because students must organize the

data before it can be counted. Mrs. Shupe's instruction for this ballot method followed the explicit teaching approach previously described for the other two surveying methods. Six data investigation lessons were conducted in this fashion with students' performance averaging 89% accuracy.

Phase 7: Plan and Teach Students How to Develop Tables and Graphs to Display Survey Data (Goal 2*)*

Once instruction related to goal one was complete, the emphasis shifted to goal two (i.e., Given questions requiring limited responses, students will collect the data, summarize the results, and display the data in a table or bar graph to answer the question). Student performance data revealed that students knew how to pose questions, collect data, and summarize the results, but now they needed to learn how to display the data in a visual display (i.e., table or bar graph). Tables and bar graphs were selected for instruction because the survey data collected in goal 1 would best be represented in these types of visual displays. To teach students how to develop and record a set of data in a table or bar graph (see Objectives 2a and 2b in Table 2), Mrs. Shupe worked with one type of visual display at a time. In the advance organizer, she reviewed the characteristics of the visual display being taught in the lesson (see Figure 5 in appendices). When students were firm on the characteristics, Mrs. Shupe demonstrated how to develop the visual display using a simple procedural strategy. The strategy for developing a bar graph included four steps.

1. Draw the x and y axis
2. Mark and label each axis
3. Represent the data in bars
4. Name the graph

Independent practice was configured this way to maximize engagement and practice for all students.

Guided practice followed the demonstration. Here Mrs. Shupe prompted students to recall one step at a time and then *perform* the step. For example:

Mrs. Shupe: What's the first step, everyone?
Students: Draw the x and y axis
Mrs. Shupe: Good remembering! Go ahead and do that on your graph paper (teacher circulates, monitors, and provides feedback).

During the independent practice part of the lesson, students were given a set of data (previously collected in Goal 1 activities) and directed to record the data in a specified visual display (i.e., table or bar graph). When students had mastered the objective of representing a set of data in a visual display, Step 4 of the Data Investigation Strategy (see Figure 1) was altered slightly. Students were now expected to first record the data in a visual display, and then answer the question. Four sets of data were recorded in visual displays. Student performance for recording data in tables and bar graphs averaged 90% accuracy.

After teaching the six math students to represent their data visually, another opportunity arose for students to conduct a real-life survey. Mrs. Shupe used an incentive program to reward students for completing homework, improving math and reading timings, and following the class rules. All of Mrs. Shupe's students, including the six math students, had the opportunity to earn participation in an ice cream float party. Once the party had been earned, Mrs. Shupe engaged

the six math students in determining the type of ice cream float students preferred (i.e., root beer or Sprite). It was the need to identify the type of ice cream float students preferred that provided an opportunity for the math students to conduct a meaningful survey.

Table 3: Data Investigation Steps for Ballot Surveys using Unlimited Response Questions

Step 1: Formulate the question.

Step 2: Plan and collect the data.

- *a. get a container*
- *b. each person writes their choice*
- *c. take turns voting*

Step 3: Count and write the totals.

- *a. sort the votes*
- *b. write the choices*
- *c. count and write totals for each choice*

Step 4: Answer the question.

A discussion was held with the students in the math group to determine what type of survey would be most appropriate to conduct. The hand-raising method was eliminated because not all of the students that had earned the ice cream float party were present in the classroom at the same time. They came to her resource room at different times of the day. Thus, the ballot method was selected. Because the responses were limited, students suggested the first ballot method that involved having one container for root beer floats and one container for Sprite floats, with each qualified student placing a bean in the container of their choice. However, Mrs. Shupe was concerned that some voting students would change their minds. Therefore, the group agreed to go with the second ballot method because it would provide a record of the students' votes.

To conduct the survey, students prepared a voting area in the room with a single container, and cut up pieces of paper to distribute to each eligible voter. Throughout the day, the eligible voters wrote their choice on the provided paper, signed their name, and placed their vote in the designated container. The following day, students counted the votes, and because this was a group project, Mrs. Shupe showed the students how to use Microsoft Excel, a program to record and present the data in a bar graph (see Figure 6 in appendices). By counting the votes and displaying the data in bar graph form, the students learned that root beer was the favorite kind of ice cream float. Mrs. Shupe's students had a great time at their ice-cream party!

Final Thoughts

Teaching students to collect data to answer questions is an important life skill that will serve them well throughout their adult lives. The instructional goals, objectives and lesson procedures described in this article provided an important foundation for understanding the concepts of data and data collection. This instruction helped students see the important connection between collecting data

and answering questions. Students also learned strategies for conducting data investigations and recording the data in a variety of visual displays. The performance of all students improved to an average of 90% accuracy on all objectives and goals which helped students not only meet their IEP goals, but also AYP expectations. In addition, students said that collecting the data and making the visual displays "Was really fun!"

Several implications for practice emerged from Mrs. Shupe's experiences with her six math students. First, she realized that just because students can answer questions about data collection methods, graphs, and tables on a state mathematics exam does not ensure that they understand and/or can apply the bigger ideas associated with the use of various data collection and data analysis procedures to answer real life questions. It is insufficient to teach students to answer test questions accurately without ensuring that they can apply the information in real world settings. Fortunately, Mrs. Shupe understood this and was willing to allocate additional instructional time to be sure that her students could use what they had learned in meaningful ways.

A second practical implication that Mrs. Shupe learned was the importance of using explicit instruction for teaching an important mathematics skill that has been somewhat overlooked in the mathematics literature. Recent changes in litigation (e.g., NCLB and IDEA) mandate that students with disabilities have access to and progress through the general education curriculum. This means that students with disabilities now face a broader mathematics curriculum that includes content areas such as data analysis. Mrs. Shupe now realizes that using explicit instruction, an approach frequently used for mathematics skills such as computation, also works for teaching data analysis.

A third practical implication that Mrs. Shupe learned was that students with mathematics disabilities enjoy being actively engaged in the instructional process and they can succeed in mathematics skills associated with the general education curriculum. She now understands the value of linking mathematics to real-world applications. She is pleased that her students learned an important skill that will be used throughout her students' future lives. As these concepts and skills are developed further in subsequent grades, these students will be better prepared to pursue complex questions, use sophisticated methods of data collection, and make wise data-based decisions.

References

Butler, F. M., Miller, S. P., Lee, K., & Pierce, T. (2001). Teaching mathematics to students with mild-to-moderate mental retardation: A review of the literature. *Mental Retardation, 39*(1), 20-31.

Hudson, P. and Miller, S. P. (2006). *Designing and Implementing Mathematics Instruction for Students with Diverse Learning Needs*, Boston: Allyn & Bacon, an imprint of Pearson Education.

Individuals with Disabilities Education Improvement Act of 2004, 20 U. S. C. § 614 et seq.

Kroesbergen, E. H. & Van Luit, J. E. H. (2003). Mathematics interventions for children with special educational needs. *Remedial and Special Education, 24,* 97 - 114.

Maccini, P., & Hughes, C. A. (1997). Mathematics interventions for adolescents

with learning disabilities. *Learning Disabilities Research & Practice, 12,* 168-176.

Mastropieri, M. A., Scruggs, T. E., & Shiah, S. (1991). Mathematics instruction for learning disabled students: A review of research. *Learning Disabilities Research & Practice, 6,* 89-98.

Miller, S. P. (2002). *Validated practices for teaching students with diverse learning needs and abilities.* Boston: Allyn & Bacon, an imprint of Pearson Education.

Miller, S. P., Butler, F. M., & Lee, K. (1998). Validated practices for teaching mathematics to students with learning disabilities: A review of literature. *Focus on Exceptional Children, 31*(1), 1-24.

Miller, S. P. & Hudson, P. J. (2007). Using evidence-based practices to build mathematics competence related to conceptual, procedural, and declarative knowledge. *Learning Disabilities Research & Practice, 22,* 48 - 58.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (2006). *Curriculum focal points for prekindergarten through grade 8 mathematics: A quest for coherence.* Reston, VA: Author.

No Child Left Behind Act of 2001, 20 U. S. C. § 6301 *et seq*.

Rosenshine, B. (1995). Advances in research on instruction. *Journal of Educational Research, 88,* 262 - 268.

Swanson, H. L., & Hoskyn, M. (2001). A meta-analysis of intervention research for adolescent students with learning disabilities. *Learning Disabilities Research & Practice, 16,* 109 -119.

Williams, T. R. & Butterfield, E. C. (1992). Advance organizers: A review of the research, Part I. *Journal of Technical Writing and Communication, 22,* 259 - 272.

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Appendices: Figures 2 - 6

Figure 2: Collecting Data for Limited Response Questions

Are hamburgers, pizza, or hot dogs the favorite cafeteria lunch for students in the first math group?

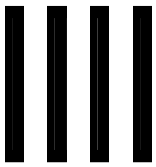
 Hamburgers	
 Pizza	
 Hot dogs	

Figure 3: Independent Practice Data Collection Form

Are gummy bears or chocolate your favorite Valentine's Day candy?

Gummy bears

Chocolate

Figure 4: Ballot Method

Is blue, red, or green the favorite color of students in the group?

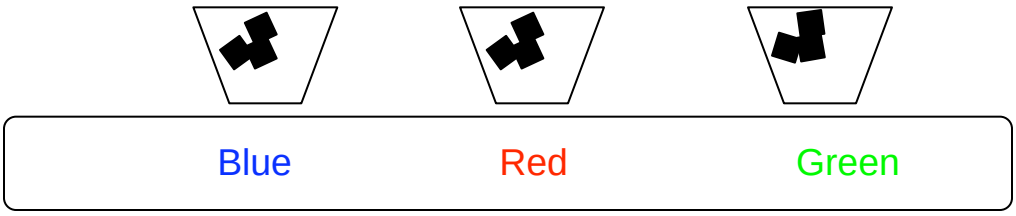


Figure 5: Table and Bar Graph Examples and Characteristics

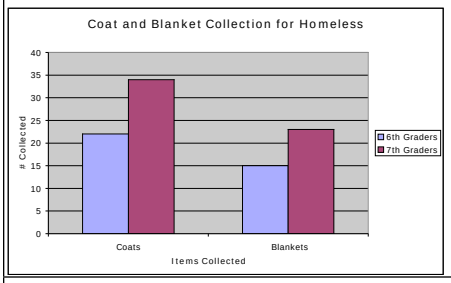
Example Display	Characteristics
Bar graph  	√ Used to display categorical information √ Has an x and y axis with one axis for category and one axis for quantity √ Data are shown in parallel bars
Table February Temperatures in Utah Year High Lows 2000 38 -7 2001 39 - 15 2002 41 - 10	√ Used to show quantity or frequency √ Has columns and rows √ Data are shown numerically

Figure 6: Ice Cream Party Survey Results