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Using an Online Tool For Learning About and Implementing Algebra Progress Monitoring

Anne Foegen, Pamela M. Stecker, Vincent R. Genareo, Renée Lyons, Jeannette R. Olson, Amber Simpson, John Elwood Romig, and Rachel Jones

Success in mathematics, especially in algebra, has been linked to high school completion, access to postsecondary education, and successful career outcomes (Adelman, 2006; Allensworth & Easton, 2005; Ma & Wilkins, 2007). The Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council for Chief State School Officers, 2010) address algebra learning across the K–12 spectrum, from algebraic thinking in the elementary grades to expressions and equations in the middle grades to algebra in high school. Despite this emphasis, few assessment options are available for teachers who wish to monitor the progress of their students in algebra learning (Foegen, Jiban, & Deno, 2007).

An extensive research base supports curriculum-based measurement (CBM; Deno, 1985, 2003) as an evidence-based practice to monitor progress and improve student outcomes (Stecker, Fuchs, & Fuchs, 2005). CBM is distinguished by three features (Stecker et al., 2005). First, students are assessed on progress toward long-term goals using parallel measures of constant difficulty. The measures are designed to be teacher-friendly because they are quick to administer (often less than 10 minutes) and have efficient scoring procedures. Second, the measures are administered frequently and scores are depicted on a graph to support instructional decision making. Finally, such measures have documented technical adequacy, so teachers can trust that the scores they obtain have evidence of reliability and validity. Research on CBM has been done in mathematics at K–12 levels, particularly, elementary (Fuchs et al., 2007; Fuchs, Fuchs, Hamlett, & Stecker, 1990), but also at middle (Foegen, 2000, 2008b; Foegen & Deno, 2001) and high school (Foegen, 2008a; Foegen & Morrison, 2010).

We encourage teachers to consider the research evidence supporting the instructional and assessment tools they choose to use.

Implementing Algebra Progress Monitoring Using the PD-APM Online Tool

The federally funded Project AAIMS: Algebra Assessment and Instruction: Meeting Standards (Foegen, 2003) supported the development of three types of algebra progress-monitoring measures that produce consistent results (are reliable), align with other measures of algebra achievement (are valid), and are sensitive to student growth in mathematics (Foegen, 2008a; Foegen & Olson, 2007a, 2007b; Perkmen, Foegen, & Olson, 2006a, 2006b, 2006c). It also facilitated the development of materials for use in implementation. Given the research demonstrating evidence of the quality of the measures, Foegen and colleagues have been providing face-to-face professional development workshops for teachers across the country to support their use. Trainers travel to the district or agency to offer workshops at a nominal cost. Following the training, participants have unlimited access to the algebra progress-monitoring materials for use in their classrooms. Although these efforts have met practitioners' needs, the face-to-face workshop format is not a viable option for some teachers due to limited district budgets.

In order to increase access to the measures, Foegen and colleagues, with support from U.S. Department of Education funding, developed the Professional Development for Algebra Progress Monitoring (PD-APM) system. PD-APM is an online system (see http://www.education.iastate.edu/pdapm/) that includes two "hubs" that support teachers as they learn about and implement the developed materials. The first is a Professional Development hub that includes 10 self-paced, interactive learning modules. The modules provide educators with foundational knowledge about CBM and show how to select among the three algebra progress-monitoring measures, administer and score them, create student graphs and reports, and analyze diagnostic data to make instructional decisions. The second is a Data Management hub that includes tools for managing student rosters, recording scores, viewing and working with student graphs, and accessing diagnostic data. In addition to supporting practicing teachers, we are investigating its use in preservice teacher preparation programs.

Step 1: Acquire Knowledge About Progress Monitoring

The first step involves learning about progress monitoring and the unique characteristics of this approach to assessment. In the PD-APM system, the first module, Core Concepts, addresses the foundational ideas essential to CBM and progress monitoring. This module is especially helpful for general education mathematics teachers who teach students with disabilities and others at risk, as they often have not received instruction on CBM or progress monitoring. It can also be a refresher for special education teachers. The second module, Project AAIMS, outlines the research and development efforts that led to the creation of the algebra progress-monitoring measures used in the system. We encourage teachers to consider the research evidence supporting the instructional and assessment tools they choose to use. Table 1 includes resources outside of the PD-APM system for readers interested in learning about progress-monitoring procedures and measures.

Step 2: Select a High-Quality Measure Related to Specific Content

The second step in implementing progress monitoring is to choose a high-quality measure, one with documented and acceptable evidence of reliability and validity. The PD-APM system includes three different algebra measures—with 12 parallel forms or probes of each type—that can be used to monitor student progress: Algebra Basic Skills, Algebra Foundations, and Algebra Content Analysis. The Algebra

Table 1. Online Resources for Progress-Monitoring Procedures and Measures Across Content Areas

Resource	Description
Center on Instruction www.centeroninstruction.org	Contains research-based sources on instruction and assessment. Provides professional development resources (e.g., PowerPoint presentations, presenters' manuals, training materials) related to special education, English language learning, early learning, literacy, response to intervention, federal priorities, and e-learning. The Science, Technology, Engineering, and Mathematics tab contains an introduction to progress monitoring in mathematics located in its Professional Development Modules and Training Materials.
The IRIS Center http://iris.peabody.vanderbilt.edu	Includes modules, case studies, activities, and evidence-based practice summaries to learn about a variety of topics, especially related to students with disabilities, ages 0 to 21. The Resource Locator provides navigation to Assessment materials, which include numerous resources on progress monitoring.
National Center on Intensive Intervention http://www.intensiveintervention.org	Provides resources related to intensifying and individualizing instruction for students with persistent learning or behavioral needs. Progress monitoring is an essential feature of this data-based individualization approach. The Tools Chart tab enables the user to look at Academic Progress Monitoring measures that have been rated by a group of experts on a variety of standards (e.g., reliability, validity, sensitivity to student improvement). The user can search the available progress monitoring tools by subject area and grade level.
National Center on Response to Intervention http://www.rti4success.org	Contains information for implementing multitiered systems of support in schools, including academics (response to intervention [RTI]) and behavior (positive behavioral interventions and supports [PBIS]). Provides information on progress monitoring as an essential component of RTI. Resources include webinars, ask-the-expert videos, training modules, family resources, glossary of terms, and publications.
National Center on Student Progress Monitoring http://www.studentprogress.org	Disseminates online resources focused solely on progress monitoring practices in several academic areas for students, grades K–5. This site contains a variety of resources, such as articles, online trainings with presentation materials and webinars, and frequently asked questions.

Basic Skills measure focuses on skills that are fundamental to success in introductory algebra courses. The Algebra Foundations measure is based on items that represent five key areas of understanding in beginning algebra courses. The Algebra Content Analysis measure is based on the skills and concepts covered in typical Algebra 1 courses with items that range from solving simple equations to solving systems of linear equations. Figure 1 includes sample items and summarizes the number of items, administration duration, content focus, and scoring procedures for each of these measures. For illustrative purposes, we focus on the Algebra Foundations measure, depicted in Figure 2. Teachers are encouraged to select the measure(s) by considering the alignment between their instructional content and the content of the measures, as well as the research evidence supporting each one. Although teachers may consider creating their own progress-monitoring measures, considerable resources and expertise are necessary to develop technically adequate tools that will produce student data that are sensitive to changes in their performance across time. Therefore, we strongly recommend that teachers use established, high-quality progress-monitoring measures, such as the ones provided in the PD-APM program.

Step 3: Administer and Score the Measure

Each algebra progress-monitoring probe is administered for either 5 (Algebra Basic Skills, Algebra Foundations) or 7 (Algebra Content Analysis) minutes. Students are instructed to consider each problem. If they do not know how to complete it, they move on to the next problem. For the Algebra Basic Skills and Algebra Foundations probes, teachers score each correct (or mathematically equivalent) response as one point. To score the Algebra Content Analysis probes, teachers compare each student's responses to a rubric and award up to three points per item based

Figure 1. Sample Items and Features for Three Algebra Progress-Monitoring Measures

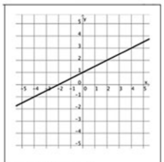
Algebra Basic Skills

Simplify: $2 + w(w - 5)$	
Solve: $\frac{r}{6} = \frac{12}{18}$	$r =$

Features of Algebra Basic Skills

- 60 items, 60 points
- 5 minutes
- Content focused on automaticity:
  - Solve simple equations
  - Use the distributive property
  - Compute with integers
  - Combine like terms
  - Use proportional relationships
- Scored using points earned in 5 minutes

Algebra Foundations



Calculate the slope ____

What is the y-intercept? ____

Evaluate $8g - 4$ when

$g = 2$ ________

$g = -2$ ________

Simplify:
$6 - 2(c - 4)$ ________

Features of Algebra Foundations

- 50 items, 50 points
- 5 minutes
- Content focused on core understandings:
  - Write and evaluate expressions
  - Calculate with real numbers
  - Graph inequalities/interpret linear equations
  - Solve simple equations/simplify expressions
  - Generalize relations and functions
- Scored using points earned in 5 minutes

Algebra Content Analysis

Solve the linear system:
$x - y = 4$
$x + 2y = 19$

A) (− 1, − 5)
B) (5, 8)
C) (− 2, 19)
D) (9, 5)

Solve for c:
$6c + 4 = -3c - 14$
$c =$

A) $-\frac{10}{3}$ B) − 2
C) 2 D) 6

Features of Algebra Content Analysis

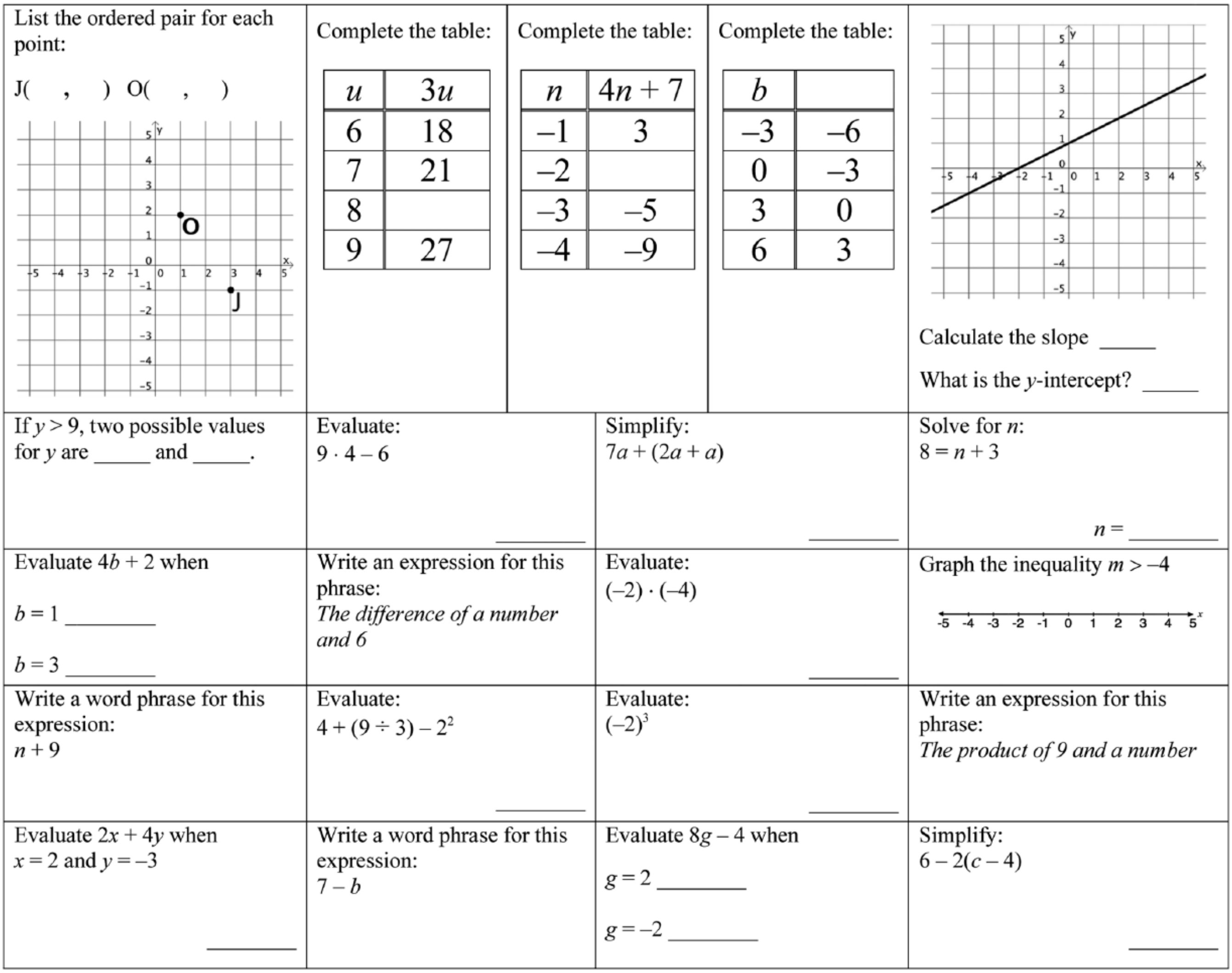
- 16 items, 48 points
- 7 minutes
- Content focused on initial concepts in Algebra 1, such as:
  - Solving equations
  - Evaluating expressions
  - Finding the slope of a line
  - Solving linear systems
  - Interpreting graphs of inequalities
- Scored using points earned in 7 minutes as determined using a scoring rubric

on the student's multiple-choice selection and the work they show. To ensure the reliability and validity of the scores gathered in progress monitoring, it is important to learn how to administer and score the probes accurately. The PD-APM modules provide hands-on activities in which teachers score a sample of student work and receive immediate feedback on scoring accuracy. In order to access the probes for classroom use, teachers are required to demonstrate a scoring accuracy level of at least 90%.

Step 4: Gather Baseline Data

The fourth step in progress monitoring, gathering baseline data, allows a teacher to determine a student's current performance levels; this procedure is done by taking the median of at least two scores from the same kind of measure near the beginning of the course. Administering several probes of the same kind of measure will provide a more stable estimate of initial performance, so teachers may opt to give two or three probes in a single week to collect baseline data across a shorter amount of time. In the top graph in Figure 3, the two blue dots represent the baseline data a teacher gathered for a student. Using the PD-APM Data Management hub, teachers can enter student scores and review initial levels of performance. This student's initial scores are 7 and 5, with a median of 6. This baseline information may be summarized on the individualized education program (IEP): "Given a 50-item Algebra Foundations measure, Jay currently

Figure 2. The Algebra Foundations Measure



List the ordered pair for each point:

J(,) O(,)

Complete the table:

u	$3u$
6	18
7	21
8	
9	27

Complete the table:

n	$4n + 7$
–1	3
–2	
–3	–5
–4	–9

Complete the table:

b	
–3	–6
0	–3
3	0
6	3

Calculate the slope _____

What is the y-intercept? _____

If $y > 9$, two possible values for y are _____ and _____.

Evaluate: $9 \cdot 4 - 6$ _________

Simplify: $7a + (2a + a)$ _________

Solve for n: $8 = n + 3$ $n =$ _________

Evaluate $4b + 2$ when $b = 1$ _________ $b = 3$ _________

Write an expression for this phrase: *The difference of a number and 6*

Evaluate: $(-2) \cdot (-4)$ _________

Graph the inequality $m > -4$

Write a word phrase for this expression: $n + 9$

Evaluate: $4 + (9 \div 3) - 2^2$ _________

Evaluate: $(-2)^3$ _________

Write an expression for this phrase: *The product of 9 and a number*

Evaluate $2x + 4y$ when $x = 2$ and $y = -3$ _________

Write a word phrase for this expression: $7 - b$

Evaluate $8g - 4$ when $g = 2$ _________ $g = -2$ _________

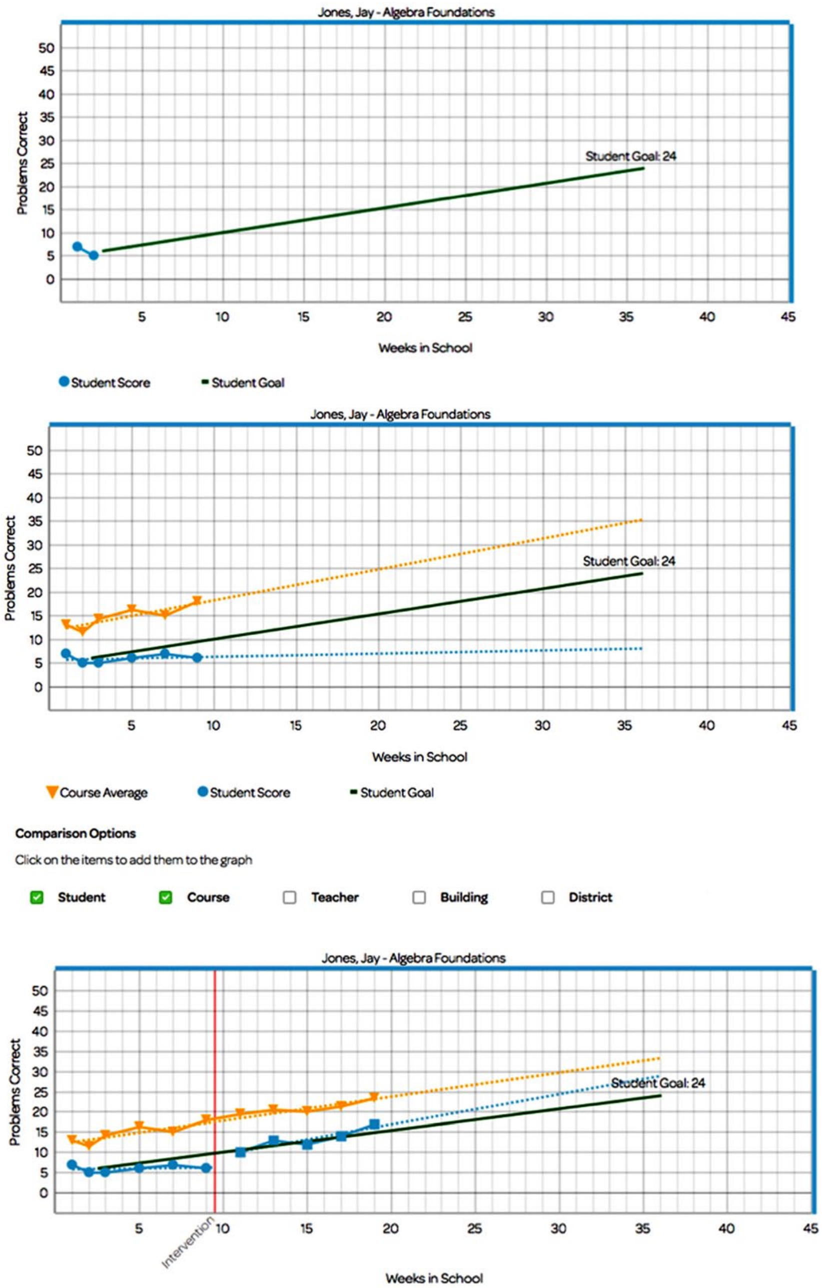
Simplify: $6 - 2(c - 4)$ _________

solves six problems correctly in 5 minutes."

Step 5: Set a Goal

Setting an individual goal for each student is the next step in algebra progress monitoring. Several methods are used to identify student goals. The first method involves the use of local norms. Scores on the measures are gathered from a representative group of students in the district and then are used to determine benchmark scores that indicate general competence in algebra when achieved. These year-end benchmarks may be used as goals. The second method involves using peer comparison data by gathering data from a small number of peers to identify scores that represent typical performance. This method may not be appropriate when a student is performing significantly below his or her peers, or if most students in the course do not demonstrate typical or desired levels of performance. The third method for setting goals is to use expected rates of growth for a particular measure. These rates of growth (i.e., average increase in number of points per week) can be used to set a goal for a student's performance. To use this method, teachers start with the student's median score from the baseline data and then add the product of the expected growth rate (approximately .5 for the Project AAIMS algebra measures) and the number of weeks until the goal is to be achieved. In the top graph in Figure 3, the student has a baseline score of 6 (starting point of the green goal line). The goal was determined by multiplying the 36 remaining weeks of the school year by an average weekly growth rate of .5 to get an increase of 18 points. This amount of increase is added to the baseline level of 6 to get a goal of 24 (e.g., 6 + [.5][36] = 24). A teacher draws a line to connect the baseline median to the goal to show the student's goal line. This goal line depicts the rate at which the student needs to progress over time in order to meet the long-term goal. A teacher may include the following goal on the student's IEP: "In 36 weeks, given a 50-item Algebra Foundations measure,

Figure 3. Jay's Baseline Data and Goal Line



Jay will solve 24 problems correctly in 5 minutes."

Step 6: Deliver Effective Instruction and Monitor Student Progress

Progress-monitoring data alert teachers to situations when their instruction is not working for a particular student. As teachers provide evidence-based instruction, they administer the algebra progress-monitoring probes on a regular basis. The frequency of administration may vary in light of student needs and intensity of services. General education teachers might use the probes once a month with their students. Students receiving supplemental instruction within response-to-intervention or multitiered-system-of-support frameworks might complete probes twice monthly or more frequently. However, for students receiving intensive intervention or special education services in mathematics, we recommend weekly administration.

Step 7: Review Student Graphs to Make Instructional Decisions

After teachers have scored and graphed several probes of an algebra progress-monitoring measure, they examine a student's graph to determine whether to modify instruction, raise the student's goal, or just continue collecting data. It is important to note that student performance on the probes is variable, and a sufficient number of scores must be collected to establish a stable estimate of current progress. After baseline data collection, we recommend teachers collect at least five to seven data points before using the data to make an instructional decision.

Although several different methods for instructional decision making are provided in the literature (e.g., see Deno et al., 2009; Fuchs, Fuchs, & Hamlett, 2015; Marston, 2012; Shinn, 2007), we encourage teachers to use trend line analysis. A trend line represents an overall rate of change (e.g., slope) in a student's data. Teachers who use trend line analysis examine the direction (positive-upward or negative-downward) and slope (steepness) of a student's trend line relative to the goal line that has been established. The second graph in Figure 3 shows a student's data in blue; the dotted blue line is his trend line. Given the current rate of growth (slope), a teacher can see that the projected level of performance will fall well short of the goal line (shown in green). This situation signals the teacher to make an instructional change in order to increase the student's rate of improvement. The PD-APM system includes a graphing tool that allows teachers to set goals, view trend lines, and also view comparison data (shown in gold in Figure 3), such as average performance of the rest of the class. It is important to note that student trend lines may change dramatically when based on a small number of data points. Consequently, we discourage teachers from making decisions using trend line analysis until sufficient data points have been collected.

Algebra Progress Monitoring in Action: Two Case Studies

Case Study 1: Ms. X and Jay

High school special education teacher Ms. X serves students with disabilities in mathematics, including many enrolled in algebra. Her students receive core algebra instruction from a general education mathematics teacher, and Ms. X provides instructional support for small groups of students in the special education setting. Until this year, Ms. X was frustrated by the lack of alignment between the eighth-grade general mathematics progress-monitoring measure her district used and the concepts her students were learning in algebra. She was excited to discover the Professional Development for Algebra Progress Monitoring (PD-APM) system and used the professional development modules to learn about several types of algebra measures and how to administer and score these assessments accurately (Steps 1 and 3). Ms. X chose to use the Algebra Foundations measure, because it most closely aligned to the curriculum she was using with her algebra support (Step 2). The top graph in Figure 3 shows the initial graph for Jay, one of her students, including his baseline data (i.e., median = 6; Step 4). Using the peer-comparison method (Shapiro, 2008), Ms. X established Jay's individualized educational program (IEP) goal (Step 5): "In 36 weeks, given a 50-item Algebra Foundations measure, Jay will solve 24 problems correctly in 5 minutes."

Ms. X's school has an alternate day block schedule, so she administers algebra probes every other Friday (Step 6). After several weeks of instruction, Ms. X noticed Jay was consistently scoring below his goal line (middle graph in Figure 3). Because Jay's trend line suggested he was not likely to meet his goal, she determined a change in instruction was needed (Step 7). Ms. X examined Jay's responses on the probes to identify common errors he was making. She noticed, and confirmed by examining Jay's skills and error analysis reports, that he was struggling with items involving the distributive property. With this information, Ms. X implemented an intervention (Step 8) that involved the use of visual representations to develop Jay's understanding of the distributive property (Gersten et al., 2009). The bottom graph in Figure 3 shows Jay's progress following the intervention (red vertical line). The trend line (blue dotted line) through Jay's scores is now steeper than the goal line (green line), which provides evidence of the effectiveness of the intervention. Using this information, Ms. X decided to continue providing this intervention while monitoring Jay's progress. If his scores approach the goal of 24 problems in 5 minutes, she will set a more ambitious goal.

Case Study 2: Mr. Y and Kay

Mr. Y also is a high school special education teacher, but he does not provide direct services to students on his caseload with mathematics disabilities; instead, he monitors their progress in algebra and consults with these students and their general education teachers to provide support for their mathematics learning. Mr. Y used the PD-APM system to learn how to administer and score the Algebra Content Analysis measure, which best fit the curriculum his students were receiving. Mr. Y's school placed a heavy emphasis on self-advocacy, with students leading IEP meetings and having input on IEP goals. One of Mr. Y's students, Kay, has a learning disability in mathematics and plans to attend a 4-year college. She completed three probes and, together with Mr. Y, set an annual goal for her IEP. Each week, Mr. Y met briefly with Kay and his other algebra students. Students completed a probe and reviewed graphs of their previous scores using the online system. Kay talked with Mr. Y about her successes and challenges in the general education algebra course, and they discussed any needed changes or interventions when the graph showed that Kay's progress was not on track to meet her end-of-year goal. At her annual IEP meeting, Kay shared data on her progress-monitoring graph and talked with IEP team members about her instructional support needs in mathematics for the upcoming school year.

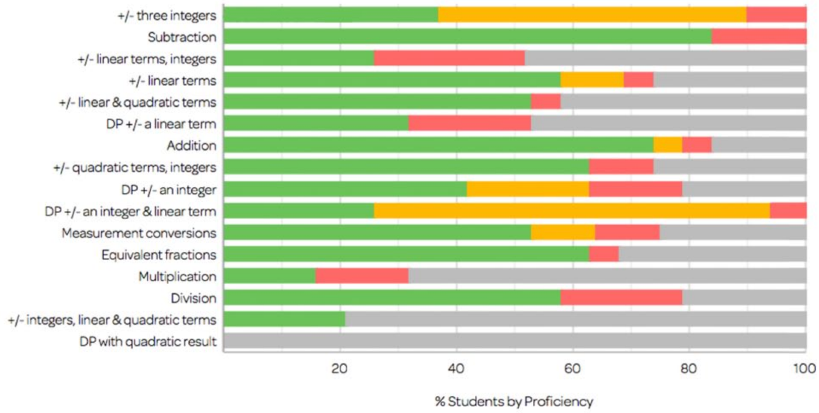
Step 8: Use Student Data to Adjust Instruction

Although progress-monitoring data signal when an instructional change is needed, the graph does not provide information about how instruction might be changed. Potential areas of change include instructional procedures, group size, materials, time, and motivational strategies. Teachers often analyze student work to determine specific skills or concepts that need to be retaught or reinforced. Using the PD-APM system, teachers can input student responses for each item on a probe to access reports about student and class performance on specific skills as well as common errors. The top chart in Figure 4 is a skills analysis report for a class that shows the proportion of students who are proficient (green), developing (yellow), or struggling (red) with each of the skills. The third line in this chart shows that about 25% of the class is proficient with adding and subtracting linear terms and integers, whereas about the same proportion is struggling with this skill. The gray portion of the bar reveals that about half of the class did not attempt any problems of this type. The error analysis report in the bottom half of Figure 4 shows that the most common errors students made in this class involved order of operations and adding or subtracting negative numbers. By analyzing student work, teachers can determine how best to change instruction for a student who is not making sufficient progress.

Why Use Progress Monitoring in Algebra?

Research supports special educators' use of progress-monitoring data for instructional decision-making purposes as an evidence-based practice for improving student achievement (see Stecker et al., 2005). The sidebar presents two case studies to illustrate how special education teachers have used the PD-APM system. Ms. X and Mr. Y worked in different instructional contexts, but both were able to use progress monitoring to support the algebra learning of their students with

Figure 4. Skills and Error Analysis Class Reports



Error Category	Students
Other	16
Order of operations	8
+/- negatives	6
Point closed/open	5
Wrong operation in equation	4
Exponent computation	3
Variable interpretation	3
Axis	2
Mult/div negatives	2
Slope formula inverted	2
Slope as ordered pair	2

disabilities. As algebra courses continue to include more secondary students with disabilities, an online progress-monitoring system, such as PD-APM, may provide efficient means for professional development while supporting teachers in their efforts to track student growth and to make instructional modifications when necessary. Regardless of which technically adequate progress-monitoring measure a teacher chooses to use, the eight steps we have described in this article should help educators better meet the needs of their students who struggle in algebra.

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Anne Foegen, *Professor, School of Education, Iowa State University, Ames, Iowa;* **Pamela M. Stecker**, *Professor, Department of Education and Human Development, Clemson University, Clemson, South Carolina;* **Vincent R. Genareo**, *Assistant Professor of Educational Psychology, Department of Teacher Education, Salisbury University, Salisbury, Maryland;* **Renée Lyons**, *doctoral candidate, Department of Teaching and Learning, Clemson University, Clemson, South Carolina;* **Jeannette R. Olson**, *Program Coordinator, School of Education, Iowa State University, Ames, Iowa;* **Amber Simpson**, *Visiting Assistant Professor, School of Education, Indiana University, Bloomington Indiana;* **John Elwood Romig**, *Doctoral Candidate, Curry School of Education, University of Virginia, Charlottesville, Virginia;* **Rachel Jones**, *Special Education Teacher, D.W. Daniel High School, Pickens County School District, Easley, South Carolina.*

Authors' Note

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Address correspondence concerning this article to Anne Foegen, Iowa State University, 1620 Lagomarcino Hall, 901 Stange Road, Ames, IA 50011-1041, USA (e-mail: afoegen@iastate.edu).

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