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Monitoring Student Progress in Algebra: Development and Evaluation of an Online Professional Development System

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This paper focuses on description and evaluation of a Web-based professional development system for teachers centered on the collection and use of frequent student performance information in algebra for instructional decision making. With U.S. federal grant funding, researchers developed Web-based instructional modules, which provided interactive instruction in the administration and scoring of three types of algebra measures. Modules also addressed use of the data management system for storing, displaying, and helping teachers to interpret data. Evaluation of this online system included feedback from nine special and general education mathematics teachers regarding their scoring accuracy, satisfaction with the content and usability of the system, and change in their knowledge about progress monitoring. In addition, a hypothetical student case study illustrates the use of this online system for informing instructional decisions within the context of a school's model for response to intervention. In this framework, teachers use progress monitoring data to identify students who are struggling, so increasingly more intensive instruction may be delivered to better meet student needs. This illustration depicts how an algebra teacher may use the online system to identify students who need more instructional support and to monitor students' progress.

***Keywords:* Algebra, Assessment, Professional Development, Progress Monitoring, Online**

INTRODUCTION

Algebra is one of students' most frequently repeated high school courses in the United States (Fong, Jacquet, & Finkelstein, 2014), with district-level ninth-grade

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failure rates in Algebra 1 reported to be as high as 44% (Ham & Walker, 1999). More importantly, failure of Algebra 1 is linked to a decreased probability of high school completion (Chiado, 2012; Fong et al., 2014). In the U.S., algebra is typically taught in the eighth or ninth grade year (e.g., 14- to 15-year-olds) and addresses concepts, such as expressions, equations, and inequalities; functions and graphs; rational exponents and radicals; and polynomials and quadratics (National Governors Association Center for Best Practices and the Council for Chief State School Officers, 2010). For students with learning disabilities, many of whom must earn credit for algebra to fulfill graduation requirements (Center for Public Education, 2013), success in algebra can be especially elusive. On the 2015 National Assessment of Educational Progress Mathematics test, only 8% and 6% of students with disabilities in grades 8 and 12, respectively, performed at the proficient level or above, compared to 37% and 26% of students without disabilities, respectively (U.S. Department of Education, n.d.). One approach that has been implemented widely in the U.S. is response to intervention (RTI; Bradley, Danielson, & Doolittle, 2007). Within this prevention/intervention model (described further below), teachers screen all students and use data to identify those at risk for poor performance and to monitor the progress of students who receive supplemental instruction, which intends to mitigate potential learning difficulties.

The purpose of this paper is to describe the development and evaluation of a technology-based system, which scaffolds teachers' learning and implementation of progress monitoring for algebra within an RTI context. We begin by providing contextual information about how RTI is used to support students who are struggling, including those with learning disabilities (see also Hinton, Flores, & Shippen, 2013). Next, we describe one specific type of progress monitoring assessment, known as curriculum-based measurement (CBM; Deno 1985, 2003). CBM frequently is implemented within RTI models (D. Fuchs & Fuchs, 2005; L. Fuchs & Fuchs, 2007) to provide evidence-based data for screening and progress monitoring. Then, we describe implementation research to situate the evaluation of an online system of professional development and data management (Foegen, Stecker, Pargas, & Witte, 2009), including explanation of our iterative field-testing process used to shape refinements to the system. Finally, we use a hypothetical case study to illustrate how RTI might be applied in a beginning algebra course and discuss further directions for research in algebra progress monitoring.

Response to Intervention

It can be challenging for teachers to determine very early in the semester which students are falling behind in a class. All too often, by the time a teacher is aware of students' struggles in mathematics, student grades are very low, and it becomes difficult to determine the specific concepts that are preventing students from succeeding. RTI is a framework that schools can use to help teachers identify and address the needs of students who are at risk early in the school year (D. Fuchs & Fuchs, 2005). The National Center on Response to Intervention (2010) identified four core components of RTI: (a) schoolwide multilevel instructional and behavioral system for preventing school failure; (b) screening; (c) progress monitoring; and (d) data-based decision making for instruction, movement within the multilevel system, and disability identification in accordance with state law (p. 1).

The multiple levels (often called tiers) in RTI systems begin with Tier 1, in which all students receive high quality, core (typical classroom) instruction using evidence-based practices. Also in Tier 1, universal screening data are gathered from all students at one (often beginning of the year) or more points during the school year to evaluate student performance. This screening process might involve reviewing state or district test results from the end of the previous year or administering an assessment to all students at the beginning of the year, which could take the form of the assessments described in this paper. Many RTI systems include universal screening at three points (early, middle, late) across the school year. When screening data indicate that a student is not responding to classroom instruction as expected, a decision is made about whether the student is in need of supplemental, or Tier 2, instruction. Tier 2 instruction typically is provided for small groups of students and represents additional instructional time beyond general classroom (i.e., Tier 1) instruction. Student responsiveness to the supplemental instruction is often evaluated by examining progress monitoring data. Brief assessments are administered frequently, and the data are graphed to provide a visual representation of changes in a student's proficiency level. If the progress monitoring data indicate that a student is not responding to Tier 2 supplemental instruction, either by slope of student progress over time or by level of performance compared to a criterion, a decision is made regarding whether the student should be moved to Tier 3 intensive intervention. In many schools, this decision includes whether the student should undergo the process of evaluation for special education services. Regardless, Tier 3 is characterized by more intensive instruction (e.g., more time, smaller group size, individualized instruction) and more frequent progress monitoring to determine whether Tier 3 instruction is meeting the student's needs. In many ways, progress monitoring represents an educational analog to child height and weight measurements, which are incorporated into well-child checkups and graphed to provide the physician and the family with a visual image of the child's physical development trajectory.

As such, data within the RTI framework are used to identify students potentially at risk, to move students in and out of tiers of instructional support, and as part of the assessment process to identify learning disabilities. Studies have shown that implementation of RTI reduced failure in elementary mathematics classrooms (L. Fuchs, Fuchs, & Hollenbeck, 2007). Knowing who is at risk for failure in mathematics allows teachers to identify problems early and to intervene in time to help these students develop adequate academic competence (Gresham & Little, 2012; Lembke, Hampton, & Byers, 2012). However, using data for decision making necessitates that the measures used are both appropriate and technically sound for screening or for monitoring student progress.

Mathematics Progress Monitoring and Measures for Algebra

Although teachers use many types of formative assessment to examine student performance and growth over time, one specific type of progress monitoring, known as curriculum-based measurement (CBM; Deno 1985), has a long history of research to support its effectiveness (see Stecker, Fuchs, & Fuchs, 2005, for a review). CBM's distinctive features include extensive research support; measures with documented reliability, validity, and sensitivity to changes in student performance; and usefulness for instructional decision making. Teachers may use CBM procedures to gather multiple, quick snapshots of student performance and may examine these data over time to evaluate student growth, much like looking at a photo album of a student across the year.

Many schools choose to use CBM for universal screening and progress monitoring within their RTI models. Frequent progress monitoring provides current information on students' progress in basic academic areas. Unlike typical classroom tests, the focus of progress monitoring is long term. A sampling of the year's curriculum typically is included in each measure, allowing for assessment of mastery and generalization of course content. The goal is to provide sound indicators of student proficiency, so teachers know when to modify their instruction if students are not progressing adequately (Deno, 1985, 2003). A review of the literature on mathematics progress monitoring measures (Foegen, Jiban, & Deno, 2007) examined measures across the K-12 grade span and identified significant gaps in available measures for middle school and high school mathematics content.

Codding, Petscher, and Truckenmiller (2014) identified four studies of middle school mathematics CBM; the content of the measures included fact fluency, conceptual understanding/application of mathematics, and estimation (Foegen, 2000; Foegen & Deno, 2001; Helwig, Anderson, & Tindal, 2002; Helwig & Tindal, 2002). Codding et al. noted that reliability estimates were high across the different types of tasks; although criterion-related validity was high for concepts, it was only moderate for facts and estimation when correlated with performance on high-stakes achievement tests. In another study, Foegen (2008) examined the technical adequacy of six types of CBM measures (Facts, Estimation, sixth-grade level Computation, sixth-grade level Concepts and Applications, Missing Number, and Complex Quantity Discrimination) from over 500 students in grades six, seven, and eight at three points during an academic year (fall, winter, spring). Consistent with Codding et al.'s findings, Foegen found that all of the measures produced acceptable levels of both alternate-form and test-retest reliability. The measures with the strongest evidence of criterion-related validity varied by grade level, with two measures having strong relations at multiple grade levels, namely the Concepts and Applications in grades six and seven and Complex Quantity Discrimination in grades seven and eight.

In this article, we highlight the use of several progress monitoring measures specifically designed for beginning algebra. These measures, Algebra Basic Skills, Algebra Foundations, and Algebra Content Analysis, were initially developed and validated through a U.S. federally funded grant (see Foegen, 2004). Although the purpose of all three assessments is to inform teachers of student academic growth in algebra content, the measures vary in content and format. These three measures provide teachers with options in the selection of a tool that they think most closely aligns with the algebra course they teach. Table 1 shows the types of problems represented on each of the algebra measures. (To download sample measures, see the project website, https://www.education.iastate.edu/aaims/).

Table 1. *Algebra Progress Monitoring Measures*

<table>
<tr><th></th><th>Algebra Basic Skills</th><th>Algebra Foundations</th><th>Algebra Content Analysis</th></tr>
<tr><td>Content</td><td>• Simple equations
• Distributive property
• Integers
• Combine like terms
• Proportional reasoning</td><td>• Writing, simplifying, & evaluating expressions
• Calculating with real numbers
• Graphing
• Solving equations
• Patterns & functions</td><td>• Simplify & evaluate expressions
• Solve system of linear equations
• Write the equation of a line in slope-intercept form
• Graph ordered pairs</td></tr>
<tr><td>Sample Items</td><td>• Solve: $12 - k = 4$
• Simplify: $4(3 + m) - 7$
• Evaluate: $8 - (-6) - 4$
• Simplify: $b + b + 2b$
• Solve for x:
2.5 cm. = 1 in.
x cm = 6 in.</td><td>• Write the expression for *6 less than a number*
• Evaluate: $4^2 + (9 \div 3)$
• Graph the inequality: $x \geq -1$
• Complete the table:<table><tr><td>h</td><td></td></tr><tr><td>–5</td><td>2</td></tr><tr><td>1</td><td>8</td></tr><tr><td>5</td><td>12</td></tr><tr><td>10</td><td>17</td></tr></table></td><td>• Simplify: $\frac{c^3d}{d^2} \cdot \frac{d^4}{c}$
• Evaluate the expression: $(3)^{-3}$
• Solve the linear system:
$x - y = 6$
$3x - y = 10$
• Write the equation of a line through points (4,2), (6,3).
• Use slope-intercept form.</td></tr>
<tr><td>Number of Items</td><td>60</td><td>50</td><td>16</td></tr>
<tr><td>Time Limit</td><td>5 minutes</td><td>5 minutes</td><td>7 minutes</td></tr>
<tr><td>Format</td><td>Constructed response</td><td>Constructed response</td><td>Multiple-choice</td></tr>
<tr><td>Scoring</td><td>1 pt. per correct item</td><td>1 pt. per correct item</td><td>–1 to 3 pts. per item</td></tr>
</table>

Source: Adapted from Foegen et al. (2009).

Over the four years of the initial grant, evidence of technical adequacy was gathered and used in combination with teacher input to make iterative refinements to the measures. In Table 2, we summarize the findings from the final two years of the initial grant. Median correlation coefficients are listed for reliability (both alternate-form and test-retest) and for concurrent and predictive criterion validity. The validity correlations were computed with respect to an algebra end-of-year test. Detailed research results are reported in Foegen and Olson (2007a, 2007b) and Perkmen, Foegen, and Olson (2006a, 2006b, 2006c). These results provided evidence that the algebra measures had sound technical characteristics.

IMPLEMENTATION RESEARCH

The research results of the initial grant, summarized in the previous section, provide evidence that algebra progress monitoring holds potential as an evidence-based practice (Council for Exceptional Children, 2014). However, the field of implementation research (Fitz, Halpin, & Power, 1994; Spillane, Reiser, & Reimer, 2002) calls attention to the fact that knowledge of a particular educational intervention or practice as evidence-based does not always result in the intervention being adopted, or "taken up," by practitioners to benefit students. Implementation is defined as "a specific set of activities designed to put into practice an activity or program of known dimensions" (Fixen, Naoom, Blasé, Friedman, & Wallace, p. 5). As a result of such activities, the adoption of a practice might occur across a continuum ranging from superficial (enough of the practice to avoid consequences associated with noncompliance), to partial or procedural (adopting aspects of the practice, but at a "lip service" level), to high-fidelity adoption, in which the practice is implemented fully and leads to tangible benefits for students.

Implementation research recognizes that adoption of new practices occurs within a community context and that the perspectives of the community play an important role in determining the success of the implementation process. Fixen et al. (2005, p. 12) offered a conceptual framework for implementation that begins with a "source," such as a specific practice, and identifies a "destination," that is, who/where/how the practice is to be implemented. These elements are connected through a "communication link," by which the developers of the practice will be "teaching" it for the destination. These three elements are connected through a "feedback mechanism" through which regular information flows between the source, communication link, and destination, with all of these elements existing within a "sphere of influence," which represents the larger context (e.g., structural, organizational, political, psychosocial). Each of these components offers a means of impact regarding the success of the adoption of the practice, as well as the effect of the practice on students. Additionally, Fixen et al. (2005) identified core components for implementation, including staff selection, preservice and inservice training, ongoing consultation and coaching, staff and program evaluation, facilitative administrative support, and systems interventions.

With respect to algebra progress monitoring as an intervention, the PD-APM system described in this paper functions as the communication link between algebra progress monitoring (the source) and algebra teachers (the destination). Regarding the implementation components, the online professional development modules represent a means of preservice and inservice training, and the data reported here provide a preliminary program evaluation. Given the iterative development of the online system within the context of our grant project, it was premature to examine the sphere of influence, as the adoption of the system was initiated through the work of the grant, rather than being driving by formal policy or grass-roots needs. In the following section, we outline the components of the PD-APM system and then move on to a description of the evaluation study.

Table 2. ***Median Coefficients for Reliability and Validity***

	Algebra Basic Skills	Algebra Foundations	Algebra Content Analysis
Reliability			
Alternate-form	.81	.84	.79
Test-retest	.83	.84	.77
Criterion Validity			
Concurrent	.53	.57	.58
Predictive	.56	.58	.54

PROFESSIONAL DEVELOPMENT FOR ALGEBRA PROGRESS MONITORING

Professional Development for Algebra Progress Monitoring (PD-APM; Foegen et al., 2009) was funded by the Institute for Education Sciences in the U.S. Department of Education as a Development and Innovation grant. The goals of the project were to create online professional development modules and data management tools, which would support teachers as they learned about and implemented progress monitoring in algebra. The PD-APM system was developed to complement and enhance teacher access to the three algebra progress monitoring measures (described in Table 1), which resulted from the earlier work.

The PD-APM system includes a professional development hub comprising 10 multimedia, interactive modules that provide users with information about (a) basic concepts in progress monitoring, (b) administration and scoring procedures for the three types of algebra measures, (c) interpretation of progress monitoring data to support instructional decision making, and (d) tools and features available within the data management system. Each module incorporates opportunities for users to check their learning by answering questions (and receiving feedback) or completing practice exercises. As users learn about each type of algebra measure, they perform a simulation activity in which they complete the measure in the same way their students would. Then, they practice scoring measures for which they receive feedback on their accuracy, and, finally, they complete a criterion exercise on which they must obtain 90% scoring accuracy to gain access to the full set of measures and scoring keys for classroom use.

The PD-APM data management hub includes tools for creating and editing class rosters, recording students' scores on the measures, and viewing graphs of student progress (refer to Figures 2 and 3 below). Within the graphing system, users can set end-of-course goals for students and record instructional changes they make in response to the progress monitoring data. An optional feature generates diagnostic data reports showing individual student and class performance on specific sub-skills within each measure as well as common errors that teachers note in students' work.

EVALUATION OF THE ONLINE SYSTEM

Initial Development Procedures

The final version of the PD-APM system resulted from a multi-year, iterative development process across two universities (see Foegen et al., 2014). First, we used "in-house pilots" involving undergraduate and graduate students in mathematics education and special education at each of the universities. The pilot university students completed a set of three modules, first under a supervised condition in which a graduate research assistant noted the time needed to complete each module, responded to any questions or technical difficulties, and administered a feedback form to collect the students' initial impressions of the modules. In a second round of review, students returned to the modules at a later time and used a commenting feature within the software to provide feedback directly on each page. The in-house pilot process allowed us to identify needed revisions in navigation, audio quality, and delays in loading video and other content on particular pages.

Following the in-house pilot stage, we used the same two-round review procedure with two different cohorts of classroom teachers. The first group included eight teachers (four from each state), who reviewed the first five modules. Their initial perceptions were quite positive, although shifting our review process to public school environments revealed new challenges with internet speed and restrictive technology policies in some schools (e.g., teachers were not allowed to download the free browser on which our system had been optimized to their school computers). The next cohort comprised five teachers, who used the same two-round review process to evaluate the first seven professional development modules. The substantive feedback from these cohorts included the recommendation that we use a single narrator for all modules. (Previously, we had been rotating among three project staff members.) Content and structural feedback was relatively minor and suggested that our efforts to incorporate the earlier feedback into the development of subsequent modules largely had been successful. In addition, teachers' questions and suggestions about the modules, which covered the online data management tools, provided valuable input on future development possibilities (e.g., developing systems for entering student scores more efficiently as well as the ability to interface with the school's information system when inputting initial class lists into the algebra system).

In the next stage of our research, we were prepared to undertake a more careful evaluation of the complete system, including all of the professional development modules and the full range of data management tools. The following research questions guided our evaluation study: (a) What are teachers' perceptions of quality and ease of use of the professional development modules? (b) Did teachers' knowledge of algebra progress monitoring increase after completing the professional development modules?, and (c) To what extent were teachers able to accurately score algebra progress monitoring measures following the instruction provided in the professional development modules? The following sections describe the methods and results of this evaluation study.

METHOD

Participants

Our participants included nine teachers, four from Iowa and five from South Carolina. All were practicing teachers; three had teaching certificates in secondary mathematics, and three were licensed in special education. Three had teaching certificates in elementary education; two of these teachers also were certified in middle school mathematics and one in special education. Seven were female and all were White. Teachers had between 2 and 30 years of teaching experience ($M = 12$; $Mdn = 11$); eight of the nine had earned a master's degree.

Measures and Analysis

We gathered data on three measures. To address the first research question, we used a Module Feedback Form, which included Likert-type scale ratings (1 = *poor*, 5 = *excellent*) to evaluate users' satisfaction with the quality and usability of 10 aspects of the professional development modules. Descriptive statistics were used to summarize the ratings. The remaining two measures were used to evaluate the efficacy of the modules in fostering learning of the desired content. To address the second research question, we used a researcher-developed PD-APM_Knowledge Test, which included 25 multiple-choice items reflecting the instructional content and skills presented in the professional development modules. We examined the significance of changes from pre- to posttest using a paired *t*-test. Finally, for the third research question, we evaluated teachers' scoring accuracy on the algebra progress monitoring measures. We collected scored student papers and checked the accuracy with which teachers had applied the scoring rules. We rescored each item and determined whether or not each teacher's scoring was in agreement with ours. We used point-by-point interobserver agreement (Salvia, Ysseldyke, & Bolt, 2012) to calculate scoring accuracy for each student paper by dividing the number of agreements by the sum of the agreements and disagreements (i.e., the total number of items scored).

Procedures

This evaluation study was conducted during the second half of the algebra course, when teachers were well acquainted with their students. Prior to teachers' use of the modules, a graduate student met with each participant to administer the PD-APM Knowledge Test as a pretest and to ensure that teachers were able to get logged into the system. Teachers then completed the modules online at times that were convenient for their schedules. The Module Feedback Form was inserted into the modules as an electronic form in three places: after Cluster 1 (Modules 1-3), Cluster 2 (Modules 4-7), and Cluster 3 (Modules 8-12). After learning how to administer and score each of the three types of measures, teachers administered one form of each type of measure to a class of students and scored the results. Then they used the data management tools to set up their class in the online system, to record their students' scores, and, for three target students, to enter item-level data and common errors into the system. At the conclusion of the study, graduate students administered the PD-APM Knowledge Test again as a posttest and collected all scored progress monitoring measures.

EVALUATION RESULTS AND DISCUSSION

Research Question 1: Teacher Perceptions of Quality and Usability

Teachers' ratings of the quality and usability of the modules (Table 3) were generally positive, with mean scores across the items and clusters ranging from 3.6 to 4.8 on a 5-point scale. Ratings for the first cluster of modules, which addressed key concepts about progress monitoring and the development process for the measures, were lower than those for the Cluster 2 modules, which addressed administration and scoring of each of the three types of algebra progress monitoring measures, and lower than the Cluster 3 modules, which addressed the use of the data management system. Users were most positive about the organization and difficulty levels across all modules, as evident in mean ratings equal to or greater than 4.5 for each cluster. They expressed the lowest levels of satisfaction (*M* = 4.1 or less) with the quality of the animation used within the modules. It is important to note that the lowest mean score of 3.6 was still well above the midpoint of the scale (i.e., 2.5), which represented moderate levels of satisfaction.

Table 3. ***Mean Teacher Ratings on the Module Feedback Questionnaire***

Questions	Cluster 1 Mean	Cluster 2[a] Mean	Cluster 3 Mean	Overall Mean
Your overall level of satisfaction with this module.	3.9	4.1	4.3	4.1
The organization of the module.	4.8	4.8	4.5	4.7
The appropriateness of the module's level of difficulty.	4.7	4.5	4.5	4.6
The clarity of the content in the module.	4.3	4.4	4.6	4.4
The quality of the graphics used in the module (clarity, contributes to understanding).	3.6	4.0	4.4	4.0
The quality of the animation used in the module (clarity, audibility, contributes to understanding).	3.8	3.6	4.1	3.8
The quality of the audio narration used in the module (clarity, audibility contributes to understanding).	3.9	4.0	4.3[b]	4.1
Your level of engagement while working on this module.	3.8	4.3	4.1	4.1
Your level of understanding of the content.	4.2	4.3	4.3	4.3
The ease with which you could navigate through the system.	4.1	--[c]	--[c]	n/a

Note. Nine teachers rated items using a Likert-type scale of 1-5 with 1 = *poor*, 5 = *excellent*.
[a]*n* = 8; [b]*n* = 7; [c]data unavailable due to technical issue with server

Research Question 2: Teachers' Knowledge of Algebra Progress Monitoring

At pretest, the mean score on the PD-APM Knowledge Test was 7.4 items correct (maximum possible score = 25). Following completion of the professional development modules and their use of the data management tools to work with their students' data, teachers' posttest PD-APM Knowledge Test mean score was 18.8, a statistically significant increase, $t(8) = 10.49$, $p < .001$.

Research Question 3: Teachers' Scoring Accuracy

For all three measures, we computed each of the nine participating teachers' scoring accuracy. For Algebra Basic Skills, we checked 32 student papers, and the mean scoring accuracy for the nine teachers was 100% (no errors in any papers). For Algebra Foundations, we rescored 34 student papers; across the nine teachers, we obtained a mean scoring accuracy of 94% (range = 63-100%). For Algebra Content Analysis, we rescored 27 papers across eight teachers and obtained a mean scoring accuracy of 97% (range = 88-100%). We discarded data from one teacher who clearly had not completed the module with fidelity, as indicated by this teacher's markings of correct and incorrect student answers rather than the assignment of full or partial credit as specified in the training module for Algebra Content Analysis scoring procedures (i.e., scores of 3, 2, 1, 0, or -1 should have been obtained for each item).

Evaluation Summary

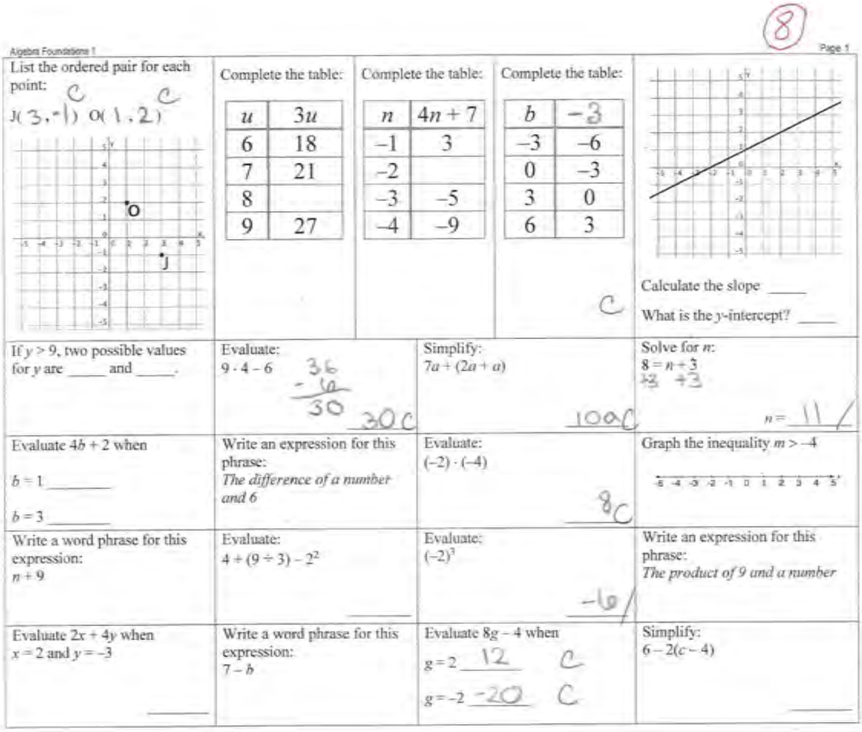
Our results indicated that the teachers in the evaluation study found the professional development modules to be engaging; that they led to greater understanding of progress monitoring; and that they were of strong quality with respect to organization, audio/video/graphic features, and ease of navigation. The participants' self-evaluations of their level of understanding of the content were corroborated by pre- to posttest gains, which documented statistically significant improvement in their content knowledge. In addition, the participants' mean scoring accuracy (ranging from 94-100%) also demonstrated that the modules were effective in providing the knowledge and skills necessary for scoring three different types of algebra progress monitoring measures. Thus, we concluded that teacher satisfaction with the modules was high and that completion of the modules led to measurable gains in teacher knowledge of algebra progress monitoring, including the ability to accurately score the measures. In the following section, we present a hypothetical case study to illustrate how a teacher used the PD-APM system to support her efforts to learn about and implement algebra progress monitoring in her classroom.

MS. SANCHEZ'S CLASSROOM: AN APPLICATION OF RTI

Ms. Sanchez taught mathematics at a school that used RTI to identify students who may be at risk for poor learning outcomes. She accessed the PD-APM professional development hub to learn how to administer and score three types of algebra progress monitoring measures and how to use the online data management system. She used the data management hub to review her students' data online while tracking their progress over time. One student in particular, Abigail, stood out to Ms. Sanchez because of her low initial screening score. This low score provided Ms. Sanchez with an early alert to pay special attention to Abigail and the other students who the initial screening had identified as potentially at risk.

Snapshots of Abigail

Ms. Sanchez began the year by delivering the same high-quality instruction to all of her students. For Algebra I classes, she used Algebra Foundations to track her class' success on foundational algebra concepts. Ms. Sanchez selected the Algebra Foundations measure because she thought that the content (see Table 1) represented the skills most important for success in her algebra class. However, Ms. Sanchez paid extra attention to Abigail and to the others identified as being at risk on the RTI universal screening tool. She looked for improvement in their Algebra Foundations scores over time. If she did not see improvement, she knew an intervention was needed. See Figure 1 for a sample of Abigail's performance on the first of two pages of an Algebra Foundations measure.



Algebra Foundations 1

8

Page 1

List the ordered pair for each point:

C C

J(3,-1) O(1,2)

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
–3	–6
0	–3
3	0
6	3

C

Calculate the slope _____

What is the y-intercept? _____

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

Evaluate:
$9 \cdot 4 - 6$

36
-6
30

30 C

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

10a C

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

$n =$ 11 /

Evaluate $4b + 2$ when

$b = 1$ ________

$b = 3$ ________

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

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

8 C

Graph the inequality $m > -4$

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

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

____

Evaluate:
$(-2)^3$

-6 /

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

$g = 2$ 12 C

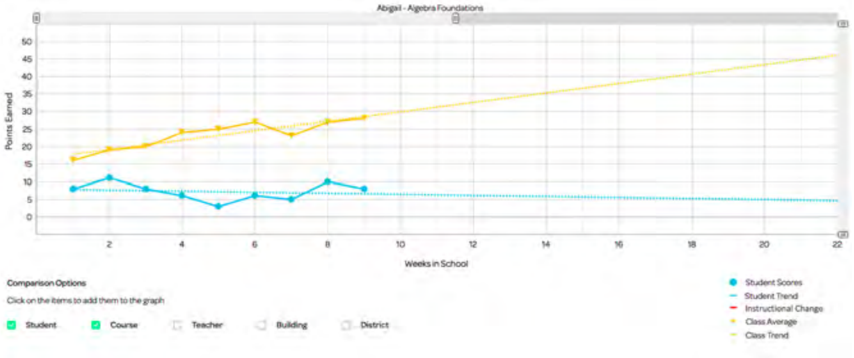
$g = -2$ -20 C

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

____

Figure 1. **Abigail's Performance on Algebra Foundations**

After nine weeks of Tier 1 instruction, Ms. Sanchez looked at Abigail's individual progress and compared it to the overall progress of the class. Figure 2 shows Abigail's graphed performance in comparison to her peers' scores. Ms. Sanchez saw that Abigail's performance (bottom line) fell substantially below the average of her peers (class average in top line) and that she did not show improvement during the previous nine weeks. That is, Ms. Sanchez noticed that the dashed trend line through Abigail's data points was relatively flat. In contrast to Abigail's performance, the average scores of her peers increased over time.



Comparison Options

Click on the items to add them to the graph

☑ Student ☑ Course ☐ Teacher ☐ Building ☐ District

Figure 2. **Abigail's Performance Compared to the Class Average**

Time for Intervention

Abigail's rate of growth during the first nine weeks of algebra class showed that she was not making adequate progress. Therefore, based on her school's RTI process, Ms. Sanchez asked the Mathematics RTI Team to consider Abigail for Tier 2 supplemental support. The team used information from Abigail's and other students' skills analyses to identify common trouble spots and identified research-based interventions targeting these specific skills. Abigail was assigned to a Tier 2 intervention group with four of her classmates; the group met four times a week for about 20-25 minutes with Ms. Sanchez during a study hall period. Ms. Sanchez worked with these five students and continued to monitor their progress. After nine weeks of intervention, Ms. Sanchez reviewed the graphed data again (see Figure 3) to examine Abigail's growth and to gauge the effectiveness of this Tier 2 intervention. Following the instructional change (depicted by the vertical line), the trend line through Abigail's scores provided evidence of effectiveness: The slope of Abigail's trend line was steeper than the class' average slope. Although Abigail's scores on the Algebra Foundations measures still fell below the average of her classmates' scores, Abigail's trend of improvement during the Tier 2 intervention showed that Ms. Sanchez's supplemental instruction was helping Abigail to close the gap between her performance and that of her peers.

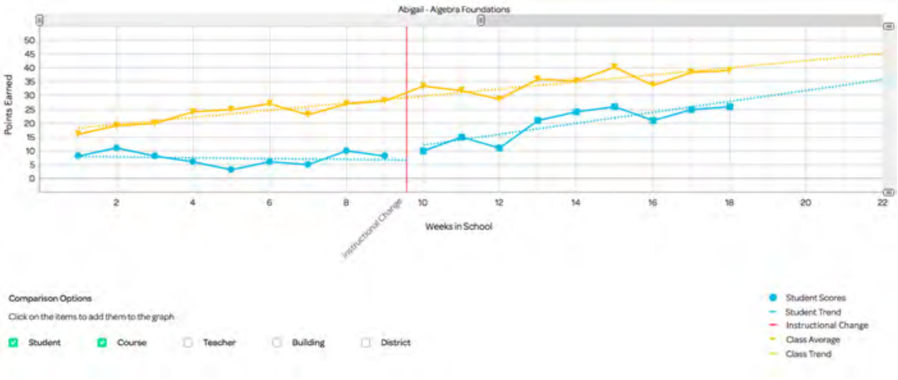


Figure 3. **Abigail's Scores and Trend during Supplemental Instruction**

Fortunately for Abigail, the Tier 2 intervention worked well, but that scenario does not always occur. When a student fails to make adequate progress during the Tier 2 intervention, the RTI Team may decide either to implement another round of Tier 2 intervention or to move that student to a Tier 3 intervention, which involves individualized, intensive intervention that targets the student's skill deficiencies. Depending on the school's RTI model, inadequate response to Tier 2 also could trigger that student's referral for special education evaluation.

CONCLUSION

Because competence in algebra is a significant concern in the United States (see National Mathematics Advisory Panel, 2008) as well as other nations, progress monitoring procedures, especially embedded within a RTI context, may provide schools with procedures for identifying learners who potentially are at risk for learning disabilities. In addition, these procedures provide a structure for delivering needed assistance before a student has fallen significantly behind peers or has failed.

This paper described the evaluation of an online professional development system, which allows teachers to acquire knowledge and skills for implementing algebra progress monitoring with their students as well as web-based data management tools for using student progress data to inform instructional decisions. The results of the evaluation of the system by a group of nine teachers demonstrated that they generally were satisfied with the organization, quality, and effectiveness of the instructional modules. A content knowledge test, given before and after their completion of the modules, showed statistically significant gains, which supported the conclusion that the modules were effective in helping teachers learn about algebra progress monitoring and the online system. Finally, an analysis of teachers' accuracy in scoring students' algebra measures suggested that teachers were able to learn how to score accurately the three types of measures after completing the modules.

In the hypothetical case study, the weekly snapshots of Abigail's progress monitoring in algebra capture the story of her success in beginning Algebra. Her teacher, Ms. Sanchez, used an algebra progress monitoring measure as a screening tool to identify Abigail as at risk for failure early in the semester. As weeks passed, scores on the weekly algebra progress monitoring measures demonstrated that Abigail was not making sufficient progress in Tier 1 instruction, so Ms. Sanchez intervened by providing supplemental instruction. Her decision to intervene was based on graphed data, and the intervention was early enough to prevent serious algebra deficiencies from developing. With the availability of algebra progress monitoring measures and tools within the online system described in Abigail's scenario, teachers may use student data to make meaningful decisions about the effectiveness of their instruction. The use of progress monitoring data may help teachers to better meet the needs of all students (National Council of Teachers of Mathematics, 2014), providing them with opportunities to be successful in algebra.

Limitations and Recommendations

A primary limitation of the present study was the small number of participants within two states of the U.S., thereby restricting the external validity of the findings. Additional research with larger samples and across multiple contexts is needed to verify the findings reported here.

Although results of our evaluation study suggest that the PD-APM system is an effective means for providing teachers with the knowledge and skills to implement algebra progress monitoring in their classrooms, continued research is warranted to investigate whether teachers can use this system to effect significant gains in their students' algebra achievement. Additionally, more studies are needed to examine the long-term impact of algebra progress monitoring training on teachers' continued use of this practice in their classrooms. Past studies of progress monitoring (see Stecker et al., 2005) indicated that teachers who were responsive to student progress monitoring data were able to effect better achievement gains among their students than teachers who did not collect progress monitoring data or than teachers who did collect such data but did not use it to influence their instructional decision making. Consequently, collecting algebra progress monitoring data and using the PD-APM system for data management are only the first steps within the larger context of providing instructional support to students who are struggling academically. Teachers also need to examine student data regularly and to consider both level of performance and trend of progress when determining whether supplemental or intensive intervention may be necessary. Like the scenario with Abigail, when progress is inadequate, teachers should take into account individual data patterns when planning instructional modifications. The PD-APM data management system is a ready tool for helping teachers with collecting, storing, and displaying student data, including relative mastery of specific skills or possible common student errors; thus, a database is provided for making instructional decisions. Although the system helps teachers with determining when students are in need of instructional modifications, it does not address the nature of those instructional changes. Consequently, research also should address whether teachers are able to use such a system on their own successfully or whether some form of ongoing support is needed for sustaining progress monitoring and for providing more effective algebra instruction.

From an implementation research perspective (Fixen et al., 2005), the evaluation study reported here focused on the source (i.e., algebra progress monitoring practices), the communication link (i.e., training and support through the professional development modules), and the destination (i.e., algebra teachers completing the professional development). The obtained results suggested that it is possible for teachers to use the online system to acquire information about algebra progress monitoring. To better understand and facilitate adoption of algebra progress monitoring, future research must attend to the sphere of influence within which algebra progress monitoring will be adopted, including administrative and organizational supports, such as ongoing coaching in implementation and data use; system-level expectations for teachers' use of the intervention; and structural supports to sustain teachers' initial implementation of algebra progress monitoring.

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