# Deepening Elementary Teachers' Content Knowledge in Mathematics

## A Prototype for Job-Embedded Professional Learning Driven by Real-Time Student Data

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## **Executive Summary**

o support student learning in mathematics as well as provide ongoing, content-specific professional development (PD) opportunities for elementary math teachers, the Bill & Melinda Gates Foundation provided funding for DreamBox Learning® to leverage its Intelligent Adaptive Learning™ engine, realtime student data, and Professional Development On Demand platform to create an innovative prototype environment for teacher professional learning. Over several months, DreamBox Learning researched the usage and impact of this prototype focused on deepening mathematics understanding for elementary teachers.

#### **KEY FINDINGS**

- Nearly 650 teachers across the US were given access to a professional learning prototype environment that provided them with PD recommendations from real-time student data so they could engage professional learning that was relevant to their specific classroom challenges and student needs.
- Over 11,000 students across the US in Grades 3–5 demonstrated over 30 percent more growth in mathematics topics on their grade level when they had a teacher who engaged in more PD sessions.
- District administrators reported optimism about the possibilities presented by this model of personalized PD because it provides a safe environment for independent learning, is relevant to the needs of students, and is accessible any time and anywhere.



In many states, K–6 teachers typically complete minimal preservice coursework in mathematics, and in some states less than 8 percent receive any specialized math training in college.

#### **CURRENT REALITY**

Math achievement in the US has been consistently low for decades, with only 40 percent of students in Grade 4 and only 33 percent of students in Grade 8 performing at a *Proficient* level as measured by the 2015 National Assessment of Educational Progress (NAEP) test.<sup>1</sup> According to a report from Learning Forward, annual PD spending has reached over \$2.6 billion at the federal level and over \$8,000 per teacher at the district level.<sup>2</sup> Yet research from the Gates Foundation found that only 29 percent of teachers are highly satisfied with PD, often because they have little input on the topics and it lacks relevance to their students and their practice.<sup>3</sup> In many states, K–6 teachers typically complete minimal pre-service coursework in mathematics, and in some states less than 8 percent receive any specialized math training in college.<sup>4</sup>

#### **PROTOTYPE USE CASES**

To improve student achievement and empower teachers with agency for their own professional learning of mathematics, DreamBox's PD On Demand prototype was designed so that teachers can find and easily access relevant professional learning resources as described in Table 1.

I want to more deeply understand the mathematics concepts and skills my students need and that I'm responsible for teaching. I want to use real-time reports, alerts, and notifications about the performance of my students and classes to inform my own professional learning pathways in mathematics.

I want to use my understanding of mathematics to improve my ability to adjust my lessons both during class and throughout the week, differentiate for students, and plan appropriate lessons and units for my students.

#### Table 1. General classroom teacher use cases

More specifically, the prototype enabled teachers to access PD modules in three ways, two of which are informed by real-time student data:

- 1. Understand topics they're teaching from their school or district curriculum;
- 2. Facilitate small group differentiation for groups of students engaged in self-directed learning; and
- 3. Support individual students whether they are learning below, at, or above grade level.
- 1. U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Mathematics Assessments.
- 2. Calvert, L., "Moving from compliance to agency: What teachers need to make professional learning work", Learning Forward and NCTAF, 2016, p. 6.
- 3. Bill & Melinda Gates Foundation, "Teachers Know Best: Teachers' Views on Professional Development", December 2014. Retrieved June 10, 2017 from http://k12education.gatesfoundation.org/resource/teachers-know-best-teachers-viewson-professional-development/.
- 4. Pettit-Riley, S., VanLooy, D., & Burroughs, N., "Promoting rigorous outcomes in mathematics and science education: The quest for coherence", Michigan State University Board of Trustees, 2012.

#### **PROOF OF CONCEPT**

The initial release and study of this prototype focused on math teachers in Grades 3–5 whose students were using DreamBox Learning K-8 Math and who had access to both the DreamBox Insight Dashboard and DreamBox PD On Demand modules. During the sixmonth testing phase in which the three use cases were rolled out over time, two primary analyses were completed separately for Grades 3, 4, and 5. The first analysis examined how students improved over a range of math topics for their current grade level as well as concepts taught in grade levels immediately above or below their grade. Similar to the grade level growth of students in grade level concepts when their teacher engaged in PD On Demand sessions, student growth in math topics from prior grade levels was also more than 30 percent higher than the growth of students whose teacher did not engage in any PD On Demand sessions. The second analysis focused specifically on the content that students were expected to master during the academic year in their current grade level only. By analyzing how often teachers accessed PD modules for math topics at different grade levels and correlating it with student growth in DreamBox, the initial findings suggest that students demonstrated as much as 60 percent more growth in mathematics proficiency at their grade level when they had a teacher who accessed PD modules from more than one grade level.

To improve student achievement, we must envision sustainable, innovative new models of PD that empower teachers and ensure relevant professional learning.

#### LOOKING FORWARD

To improve student achievement, we must envision sustainable, innovative new models of PD that empower teachers and ensure relevant professional learning. The DreamBox PD On Demand prototype engages teachers in a dynamic, self-paced experience that enables them to use real-time student performance data as a starting point for relevant professional learning. It represents a scalable way to deepen teachers' content knowledge in mathematics while also informing their classroom curriculum and lessons. This whitepaper describes the research informing the prototype's design, ways it integrates with broader professional learning initiatives, and recommendations for future development that can benefit education leaders as well as other providers and organizations interested in improving professional learning services for teachers.



The prototype and PD On Demand modules had the opportunity to impact the learning of a large cohort of students in mathematics.

### Teacher Use and Student Impact: Learning and Growing Together PROMISING RESULTS FROM THE DREAMBOX PD ON DEMAND PROTOTYPE STUDY

The initial proof of concept for this professional learning prototype was designed to support math teachers in Grades 3–5 whose students were using DreamBox Learning K–8 Math and who had access to both the DreamBox Insight Dashboard and DreamBox PD On Demand modules. Grades 3–5 were the focus for two main reasons:

- Elementary math teachers generally have less mathematics content and pedagogical training than in other subjects, which means they stand to benefit significantly from easy access to relevant, content-based professional learning.
- Grades 3–5 are generally the first state-tested grades, meaning that stronger support for these teachers can serve school and district student achievement goals related to key accountability measures and early intervention.

The prototype testing and data collection period began the last week of August in 2016 and ended in February 2017. During this window, DreamBox's PD prototype was released in three waves to three different groups of teachers. In all, usage data were collected from a total of 649 teachers in Grades 3–5 who engaged in 1,490 DreamBox PD On Demand sessions. These teachers were responsible for over 11,000 students who collectively completed nearly 1.3 million DreamBox lessons during the testing window. As such, the filter-down effect of the prototype and PD On Demand modules had the opportunity to impact the learning of a large cohort of students in mathematics.

The most important result from the analysis of data during the testing phase examined teacher usage of the PD On Demand modules and correlated it with the growth their students experienced in the DreamBox curriculum. \*As seen in Figure 1, when compared to the growth of students whose teachers did not engage in any PD On Demand sessions, students across Grades 3–5 demonstrated over 30 percent more growth in mathematics proficiency at their grade level when they had teachers who more frequently accessed the PD modules. These results warrant further study, as they could be a confirmation of the findings by D.L. Ball and colleagues that teachers with a stronger mathematical knowledge for teaching have students with higher levels of achievement.<sup>5</sup> The data in Figure 1 are discussed more fully in Appendix C and specifically Table 4.

<sup>5.</sup> Deborah Loewenberg Ball, Heather C. Hill, Hyman Bass, "Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide?", American Educator, Fall 2005.



# Students' grade level growth increased when teachers engaged in more DreamBox PD On Demand sessions

Because math leaders face the challenges of effectively implementing professional learning school- or districtwide, administrators have noted that this approach could be a "game-changer" that helps them truly scale and personalize PD for elementary teachers.

Figure 1. Relationship between completion of PD On Demand sessions and student growth in DreamBox

#### ADMINISTRATORS WEIGH IN: JUST-IN-TIME MATH PD IS A POTENTIAL "GAME-CHANGER"

During the prototype testing phase, administrators shared their excitement and enthusiasm for this professional learning environment and its potential to help both students and teachers. Because math leaders face the challenges of effectively implementing professional learning school- or district-wide, administrators have noted that this approach could be a "game-changer" that helps them truly scale and personalize PD for elementary teachers. For example, Catherine DeMers, a K–12 mathematics specialist in Charleston County School District in South Carolina said, "This is one of the features that really impressed me. DreamBox not only helps students learn, but it also provides teachers PD on the specific content that students are learning."

Jesse Hiett, a 21st century numeracy coordinator for the Springfield Public Schools in Missouri, is very interested in making sure teachers have professional learning opportunities for mathematics content that are easy to access and aren't intimidating for teachers who might not feel comfortable with their own math knowledge. He shared, "DreamBox's PD modules are important for these teachers. It provides them a safe environment to access the information they need to explore unfamiliar topics. Teachers appreciate how easy these items are to access without having to memorize another login. This is something I hope you continue to develop and improve." Whether or not K–8 teachers have a strong mathematical knowledge for teaching, developers need to create tools and techniques that will truly deepen teachers' content knowledge of relevant mathematics so they are well-equipped to, in turn, support student understanding and development. In the Baltimore County Public Schools in Maryland, elementary mathematics supervisor Natalie Crist is working on a plan to get DreamBox's PD On Demand modules formally approved as part of their overall district growth programming so that teachers can earn continuing professional development (CPD) credits and hours. She noted that, "While there are similar small courses in other content areas for which teachers can earn CPD credits, none of them are related to student data like the DreamBox PD On Demand modules. In addition to giving teachers a quick, easy way to boost and refresh their own skills throughout the school year, teachers really like the flexibility of being able to access the PD On Demand modules from home and in the evenings. That convenience means more teachers will access it."

As administrators continue to look for funds, time, and human resources to help improve student achievement and support student growth, next-generation professional learning models like this PD prototype environment show great promise.

# RECOMMENDATIONS FOR DEVELOPERS: FOCUS ON CONTENT AND COMMUNICATION

Throughout this whitepaper, we describe how and why we designed the PD prototype so that other developers and content providers can learn from the ideas underlying this next-generation PD model. Whether or not K–8 teachers have a strong mathematical knowledge for teaching, developers need to create tools and techniques that will truly deepen teachers' content knowledge of relevant mathematics so they are well-equipped to, in turn, support student understanding and development. At the outset, we recommend developers focus on two key areas: content and communication.

First, this prototype environment is more than just a way to generate PD recommendations for teachers using their students' data—the nature of the PD content and the way teachers learn are critically important. More often than not, programs that provide data-informed recommendations for math teachers typically only present them with a scripted classroom lesson to follow while ignoring the teacher's own understanding of the concept. If a teacher hasn't made sense of the math content in the lesson, the scripted lesson will have limited effectiveness. Consider that many adults don't understand how and why fraction division works because they were told as students, "Yours is not to reason why, just invert and multiply." In the same way that students should not be given a computational procedure without understanding the math concepts involved, teachers shouldn't be given a scripted lesson without understanding the mathematics behind the lesson.

To avoid this problem, one way the DreamBox PD modules engage teachers in understanding math concepts is by leveraging the unique virtual manipulatives and digital tools that exist in the DreamBox student experience. These dynamic and interactive representations provide new opportunities for teachers to engage with math concepts in ways that they didn't experience when they were students. These learning experiences are also in stark contrast to PD content that is merely digitized video lectures explaining math concepts to teachers without engaging them in sense-making and understanding.

According to Patricia S. Moyer and colleagues, the benefits of using these manipulatives are similar for students and teachers: "True virtual manipulatives... allow increased engagement, forcing the user to interact with dynamic objects. Through this interaction students have opportunities to make meaning and see relationships as a result of their own actions."<sup>6</sup> Virtual manipulatives offer teachers the opportunity to make sense of mathematics concepts in ways that aren't possible with pencil and paper. As teachers interact with these digital tools within the recommended PD modules, they use math processes and practices to understand concepts more deeply. At the same time, they learn to empathize with how students are developing their own conceptions in math. For these reasons, we recommend that developers engage teachers in new ways that can better improve thinking and learning in mathematics.

Second, we cannot overstate the importance of communicating with teachers around ongoing changes and innovations. During the first four months of prototype testing, we used a phased communication approach in the hopes of collecting data to learn about how quickly and easily teachers found and used the PD On Demand links on their DreamBox Insight Dashboard on their own. Considering that Netflix and Amazon don't send emails to customers every time they make small, incremental changes to their user interface, we expected these PD changes might be easily noticed and used by teachers. So, we decided to test that theory for a few weeks.

We established a control group for user comparisons in which teachers did not receive notification immediately that the PD prototype environment was available. We found that teachers were less likely to see and use the PD prototype features when they did not receive any notification about it. Given these data and considering all of the demands on teachers' time, we recommend that developers notify teachers clearly and quickly when key new features become available, either with an email or an alert notification upon logging in.

**66** True virtual manipulatives... allow increased engagement, forcing the user to interact with dynamic objects. Through this interaction students have opportunities to make meaning and see relationships as a result of their own actions."

-Patricia S. Moyer, International Conference New Ideas in Mathematics Education

6. Moyer, P. S., Bolyard, J., & Spikell, M. A., "Virtual manipulatives in the K–12 classroom", Proceedings of the International Conference New Ideas in Mathematics Education, Autograph, August 2001, pp. 184-187.

### Current Reality: The Impetus for a Just-in-Time Model of Teacher Development STUDENT ACHIEVEMENT IN K-8 MATH HAS REMAINED LOW AND STAGNANT FOR DECADES

The current reality of mathematics achievement in elementary and middle school is of concern to many teachers, administrators, and parents. In 2015, only 40 percent of Grade 4 students and 33 percent of Grade 8 students earned a score of *Proficient* or *Advanced* on the NAEP test, as seen in Figure 2 and Figure 3.

			Below Basic	Basic	Proficient	Advanced	Percentage at or above Proficient
	2015		18	42	33	7	40
	2013		17*	41	34*	8	42*
	2011		18*	42	34*	7*	40
	2009		18	43*	33	6*	39
	2007		18	43*	34*	6*	39
ear	2005		20*	44*	31*	5*	36*
¥	2003		23*	45*	29*	4*	32*
	2000		35*	42	21* 3*	k	24*
	1996		37*	43	19* 2*		21*
	1996 <sup>1</sup>		36*	43	19* 2*		21*
	<b>1992</b> <sup>1</sup>		41*	41	<b>16</b> * <b>2</b> *		18*
	<b>1990</b> <sup>1</sup>		50*	37*	12* 1*		13*
	-	400 00 7	0 00 50 40	20. 20. 40	1 10 00 0	0 40 50 00 70 0	0 00 100

100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100

\*Significantly different (*p* < .05) from 2015. <sup>1</sup> Accommodations not permitted. NOTE: Percentage-point differences are calculated based on the differences between unrounded percentages.

#### Figure 2. Trend in Grade 4 NAEP mathematics achievement-level results

The remaining 60 percent of Grade 4 students and 67 percent of Grade 8 students fell into the *Basic* and *Below Basic* categories. As shown in the figures, student achievement in mathematics has improved significantly since 1990 for students in both grades, but achievement levels have remained relatively stagnant since 2005.<sup>7</sup>

 NAEP - 2015 Mathematics & Reading Assessments retrieved from <u>https://www.nationsreportcard.gov/reading\_math\_2015/#mathematics/acl?grade=8</u>

			Below Basic	Basic	Proficient	F Advanced	Percentage at or above <i>Proficient</i>
	2015		29	38	25 8		33
	2013		26	38	27* 9	*	35*
	2011		27*	39	26* 8		35*
	2009		27*	39	26* 8		34
	2007		29	39*	25 7*		32*
ear	2005		31*	39*	24* 6*		30*
¥	2003		32*	39*	23* 5	*	29*
	2000		37*	38	21* 5	*	26*
	1996		39*	38	20* 4*		23*
	<b>1996</b> <sup>1</sup>		38*	39	20* 4*		24*
	<b>1992</b> <sup>1</sup>		42*	37	<b>18</b> * <b>3</b> *		21*
	<b>1990</b> <sup>1</sup>		48*	37	13* 2*		15*
		100 90 80 7	0 60 50 40	30 20 10	0 10 20 30	0 40 50 60 70 80 90 100	

\*Significantly different (p < .05) from 2015. <sup>1</sup> Accommodations not permitted. NOTE: Percentage-point differences are calculated based on the differences between unrounded percentages.

Figure 3. Trend in Grade 8 NAEP mathematics achievement-level results

#### FUNDING, TIME, RESOURCES, AND CURRICULUM LIMIT MATH-SPECIFIC PD OPPORTUNITIES

Despite its critical importance to student achievement, there are significant challenges to successfully implementing and scaling in-service professional learning that improves K–8 teachers' mathematical knowledge for teaching. Funding and time are often the most limiting factors, regardless of whether districts allocate professional learning hours during the school day or over the summer.

While in-service professional learning time during the school day ensures teachers can immediately apply what they're learning in the classroom, districts must pay substitute teachers to cover classes while professional learning is under way. If districts offer professional learning sessions over the summer, teachers cannot immediately apply what they learn, and districts incur both the additional expense of providing daily stipends to compensate teachers for their time as well as the cost of hiring PD consultants to facilitate the learning sessions. In addition to incurring these costs, in many schools, teachers cannot be compelled to attend summer workshops. Thus, a professional learning curriculum cannot be guaranteed for all teachers and therefore cannot be guaranteed to reach all students. KEY FINDING Only 29 percent of teachers are highly satisfied with current professional development offerings. And, principals largely share their concerns.<sup>8</sup> Even in scenarios where funding, time, and substitutes are available, the professional learning curriculum focus might not always be in mathematics, let alone in the areas of mathematics that are most relevant to each teacher at every grade level with respect to their students' needs. Furthermore, school and district leaders often have professional learning focus areas—including development of professional learning communities (PLC), differentiated instruction (DI) practices, and blended learning practices—that may distract or prevent teachers from developing their mathematical knowledge for teaching.

The DreamBox professional learning prototype environment was developed specifically to address these challenges in a scalable way that aligns with the best practices for professional learning described in Appendix A. Designed to deepen teachers' mathematical knowledge for teaching and immediately impact student achievement, the DreamBox prototype delivers professional learning content that's based on students' current needs, and can be accessed at any point during the school year from an Internet-connected device. The PD prototype enables professional learning that is highly relevant because it is informed by students' math performance, and it seamlessly integrates and supports any work with PLCs, DI, blended learning, and many other initiatives.

## CREATING RELEVANT CONNECTIONS BETWEEN TEACHER PD AND WHAT STUDENTS ARE LEARNING

Given the need to improve the mathematics achievement of the great majority of students, school and district leaders face very real challenges:

- Students in most classrooms have a wide range of prior knowledge and math proficiency, often because districts and standardized accountability tests use a student's birthdate and age to assign students to a grade level and measure their progress.
- Elementary teachers generally have less content knowledge and pedagogical pre-service and in-service training in mathematics than they do in literacy.
- Teachers don't always have access to student growth and proficiency data that are recent and relevant.
- Teachers don't always have opportunities for professional learning and development that are related to their own students' needs.
- "Few teachers (only 29 percent) are highly satisfied with current professional development offerings."<sup>8</sup>
- "Principals largely share teachers' concerns about the efficacy of professional learning."9

Research indicates that an educator's knowledge of the subject of mathematics, and understanding of methods to teach the various concepts, can improve student achievement.<sup>10</sup> To support student learning in mathematics as well as provide ongoing, content-specific PD opportunities for elementary teachers, DreamBox designed its prototype environment to engage teachers in a private, self-paced learning experience. For teachers, the PD prototype environment enables them to use their own students' real-time performance data as a starting point for focusing their own professional learning. For district and school leaders, the PD prototype represents a scalable way to deepen teachers' content knowledge at any time during the school year while also informing their classroom curriculum and lessons.

In 2016, Laurie Calvert authored a publication from Learning Forward and the National Commission on Teaching & America's Future (NCTAF) entitled, *Moving from Compliance to Agency: What Teachers Need to Make Professional Learning Work.*<sup>11</sup> In the paper, Calvert recommends seven important steps that district and school leaders can take to improve educator agency in their professional learning systems. These actions or best practices, particularly steps 3, 5, and 6 presented below in Table 2, helped to inform development of the DreamBox professional learning prototype. By connecting professional learning directly to real-time student performance data, the DreamBox prototype improves educator agency and empowers teachers to choose where and how to focus their own professional learning.

For teachers, the PD prototype environment enables them to use their own students' real-time performance data as a starting point for focusing their own professional learning.

## What district and school leaders can do to improve education agency in their professional learning systems

S T E P	Make all professional learning decisions only in serious consultation with teachers and principals. Ensure at least 50 percent teacher representation on school and district teams that are responsible for every stage of decision-making from planning and data analysis to design, implementation, and evaluation.
s t e p 2	Rethink organization of the school day so that educators have time to meet regularly to collaborate with colleagues to improve teaching and learning.
s т е р 3	Involve and support teachers in analyzing data and identifying teaching and learning challenges.
s t e p 4	Establish learning communities where educators solve problems of practice and share responsibility for colleague and student success.
s t e p 5	Give teachers choices regarding their professional learning, including who they work with and where they focus their learning.
S T E P 6	Ensure that professional learning is for the purpose of continuous growth, not evaluation.
s t e p 7	Resist the temptation to "scale up" or mandate a particular form of professional learning without thoroughly examining the context in which it will be implemented. Understand that learners must want to improve their practice and see how the learning opportunity will help them do so.

#### Table 2. Seven steps to improving teacher agency in professional learning

- 10. Deborah Loewenberg Ball, Heather C. Hill, Hyman Bass, "Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide?", American Educator, Fall 2005.
- 11. Calvert, L., "Moving from compliance to agency: What teachers need to make professional learning work", Learning Forward and NCTAF, 2016, p. 6.

Students, teachers, administrators, and schools are negatively affected when it is difficult to meet the needs of both students and teachers for improving the understanding of mathematics and gaining achievement in the subject. Because DreamBox provides a personalized learning experience for each student, teachers are able to learn about students' needs and growth in math topics that are outside their current grade level or classroom curriculum. The PD prototype environment specifically helps teachers locate and understand their students' learning needs, identify other students with similar needs, and quickly access professional learning resources to better understand the mathematics behind those topics.

By sharing our rationale, development details, and early usage data, we hope professional learning organizations, educators, researchers, and other companies can benefit from our findings. Driven by real-time student performance data, the DreamBox prototype environment empowers teachers to further their learning of math concepts in a just-in-time model of teacher development rather than a just-in-case model. We encourage other content providers to apply these learnings to their own data, reporting systems, and content to make learning recommendations for teachers. When teachers engage in a dynamic and self-paced experience using current student data as a starting point for focusing their own professional learning, they can deepen their content knowledge, improve their classroom curriculum and lessons, and ultimately improve the achievement of all students.

# Prototype Use Cases: Finding the Right PD at the Right Time Based on Student Needs

According to Calvert, "At the core of our use of the term 'professional learning' is the belief that there is an important relationship between the adults' professional learning environment and what students learn in school."<sup>12</sup> To explicitly make this connection in the prototype, we created three primary use cases for classroom teachers and two for administrators, as seen in Table 3. The initial analysis of the prototype did not evaluate the administrator use cases.

	Classroom Teacher Use Cases		Administrator Use Cases
1	I want to more deeply understand the mathematics concepts and skills my students need and that I'm responsible for teaching. I want to use real-time reports, alerts, and notifications about the performance of my students and classes to inform my own professional learning pathways in mathematics.		want to enhance my teachers' professional earning in mathematics by making it more personalized, more accessible to accommodate
2			heir schedules, and more relevant to their tudents' needs. want teachers' improved understanding of nathematics to inform their interactions with tudents and classroom curriculum decisions,
3	I want to use my understanding of mathematics to improve my ability to adjust my lessons both during class and throughout the week, differentiate for students, and plan appropriate lessons and units for my students.	as	nd to support personalized learning in the chool and district.

#### Table 3. Use cases for the DreamBox PD prototype

These use cases also align with conditions Calvert identifies as components of professional learning that support teacher agency because the topics and skills addressed are:<sup>14</sup>

- Teacher-identified learning objectives
- Based on data (including observations)
- · Focused on teachers' and students' continuous growth
- Aimed at specific classroom challenges
- · Based on teachers deciding what they need to learn

The DreamBox prototype professional learning environment is designed to achieve this goal by connecting DreamBox's three main experience components:

1. Student experience using DreamBox Learning K–8 Math. Individual students use virtual manipulatives and rigorous adaptive lessons to deeply understand math concepts and skills as they self-direct their learning path through the DreamBox curriculum and motivating, age-appropriate learning environments.

- 2. Educator experience using the DreamBox Insight Dashboard. Classroom teachers access student- and classroom-level usage, growth, and proficiency reports to inform their classroom practice or create assignments for students that are automatically differentiated by DreamBox.
- 3. Educator experience using DreamBox PD On Demand modules. Classroom teachers gain deeper insight into mathematics concepts and the DreamBox curriculum by accessing short videos, student lessons, and curricular resources.

There are three specific ways the prototype supports teachers' access to self-directed PD On Demand modules that also connect to the three use cases described in Table 3:

- Understanding the classroom-taught curriculum. When teaching a math concept to the whole class from the pacing calendar, textbook, or other source, a teacher can access PD On Demand modules for that topic to better understand the math concepts and more confidently facilitate classroom lessons for the topic.
- 2. Informing small group differentiation. When a small group of students is simultaneously working on a math concept in DreamBox that isn't being taught in class, the classroom teacher can access PD On Demand modules to understand the math concepts and facilitate a strategy group to discuss the topic.
- **3. Providing individual student support.** When examining student-level reports to support remediation, acceleration, or grade-level differentiation, the classroom teacher can access PD On Demand modules relevant to that student's needs.

#### UNDERSTANDING THE CLASSROOM-TAUGHT CURRICULUM

At any point during the school year, a teacher might need to begin units, facilitate lessons, or create assignments and assessments that are related to math topics they don't fully understand. The PD prototype is designed to support this mid-year reality by giving teachers access to the professional learning they need, whenever they need it. When a teacher uses the AssignFocus<sup>™</sup> feature to engage students in DreamBox lessons that align with what is being taught in the classroom, a link to the PD On Demand modules for that topic is visible directly next to the assigned topic, as seen in Figure 4.

	This week						
	🔁 Short-Term As	signment				(6/26	5/17 to 7/10/17, 2 weeks)
		Multiplying Decima Students multiply decim	als with Arrays PD al numbers up to the thouse	andths place using an	array as a model.		11 Students ^ cancel
	First Name 💲	Last Name	Status	Time Spent	Lesson Type	Lessons	Details
Link to PD On Demand	Betty	B (5th)	GOAL REACHED	0 minutes		1	View
module for the assigned topic	Christopher	U (4th+2)	GOAL REACHED	0 minutes		1	view
	Daniel	W (4th)	GOAL REACHED	21 minutes	Progressing	3	view
	Donald	C (5th)	GOAL REACHED	7 minutes	Review	1	View
	Dorothy	T (3rd)	GOAL REACHED	35 minutes	Progressing	5	view
	Helen	D (5th)	GOAL REACHED	0 minutes		1	View
	Thomas	S (3rd)	Not Started	-	-	0	la view

#### Figure 4. Preparing for a classroom topic when creating a small group assignment

When teachers create a short-term assignment for the entire class as homework that supports the classroom lesson or district pacing calendar for that day, they can easily learn more about the math topic the students will be focused on for that assignment. Teachers can also create a long-term assignment for a small group of students to support goals defined in response to intervention (Rtl) programs or multi-tiered systems of support (MTSS). In either case, when teachers use DreamBox AssignFocus to complement their classroom lessons, they have another way to access PD On Demand modules and improve their understanding of the topics they're teaching in class.

#### **INFORMING SMALL GROUP DIFFERENTIATION**

The PD prototype environment makes it easy for teachers to learn more about math concepts at different grade levels, based on interest or need. Powerful reporting capabilities enable teachers to meaningfully connect professional learning to the most relevant and recent student performance data. Because DreamBox aggregates real-time information in the class activity feed, teachers can see the personalized topics that groups of students have recently and independently chosen in DreamBox. Figure 5 shows a report view of math topics recently accessed by groups of students. When a teacher wants to work with one of the groups of students listed in this report view, they simply click the link to the PD On Demand module to view relevant professional learning. Immediate access to PD equips teachers to confidently discuss the math topic with those students.



KEY FINDING DreamBox's PD On Demand prototype helps teachers access relevant professional learning resources in three ways, two of which are informed by real-time student data. During early user testing of this component of the prototype, it became clear that teachers also needed an indication of whether they had previously accessed the PD On Demand modules for these specific topics. Therefore, a PD On Demand status bar was included in this visualization. Given the incredibly limited time that teachers have to access and understand the data and information they need, any amount of time savings from small features like this can help streamline the learning process.

Because individual students or groups of students using DreamBox might be working on topics below or above grade level, this visualization also provides insight for teachers in the event that multiple students are receiving acceleration or intervention support within DreamBox. Teachers want to meet the needs of all students, and it can be challenging for them to learn about content or access professional learning resources related to math topics that are not at the current grade level they're teaching.

#### ENHANCING INDIVIDUAL STUDENT SUPPORT

When gathering feedback during the PD prototype testing period, teachers indicated that they often "drill down" into the data reports for a single student. They requested access to PD On Demand modules directly from that student report in order to know how to better support each student. Figure 6 shows how teachers can immediately access professional learning to support a student that may need attention or intervention for a particular math topic. Given the need to reach and support all students, the prototype represents an innovation that enables teachers to quickly find and focus a professional learning opportunity using nothing more than the growth and needs of specific students.



## **Proof of Concept: How the Prototype Impacted Student Growth** HOW THE DREAMBOX PD ON DEMAND PROTOTYPE WAS DESIGNED AND BUILT

As described earlier, there are three components of the DreamBox Learning program that are connected in the PD prototype environment:

- 1. DreamBox Learning K-8 Math program for students
- 2. DreamBox Insight Dashboard for teachers
- 3. DreamBox PD On Demand modules for teachers

The general process and workflow that teachers follow as they use the PD prototype and these three components are shown in Figure 7.



Figure 7. General workflow of the PD prototype environment

KEY FINDING Elementary students demonstrated over 30 percent more growth on topics from prior grade levels when they had a teacher who engaged in more PD sessions. Prior to developing the PD prototype, the DreamBox student experience and educator Insight Dashboard were already connected in a meaningful way and provided teachers with realtime data about student learning. In order to make meaningful connections with the PD On Demand modules, DreamBox created new visualizations on the Insight Dashboard. DreamBox PD On Demand is available anytime, anywhere with an Internet connection, and is built using the modular object-oriented dynamic learning environment (Moodle) from Blackboard. There were technical programming challenges to ensure the DreamBox and Moodle platforms regularly exchanged and updated data to accurately track and report each teacher's progress through the PD On Demand modules. Teachers have a separate login for their DreamBox Insight Dashboard and their PD On Demand account with Moodle. So another essential technical component of the connection between DreamBox and Moodle was creating a single sign-in experience so that teachers could directly access PD On Demand content without being required to log in to the Moodle platform.

#### HOW TEACHERS ACCESSED PD ON DEMAND MODULES



Figure 8. Teacher PD sessions and module engagement by access method

Though more PD On Demand sessions were initiated on the Insight Dashboard, the early usage data revealed that teachers engaged in more modules during a single session when they accessed them via direct Moodle login. This behavior could be an indication that teachers reviewing student data only needed a small amount of PD content at the time. Or it could be evidence that teachers who had already decided to use the Moodle platform as part of a formal PD program from the beginning of the school year continued accessing modules that way in order to follow through on their plans. In addition, the PD prototype features in Figures 4–6 were rolled out over time, and weren't all available when the prototype was first released for feedback. Had the PD On Demand modules been accessible in some of those locations on the Insight Dashboard from the very beginning, perhaps the users accessing modules via the Moodle platform might have used the Insight Dashboard instead. For further analysis of these data, see Appendix C, specifically the discussion of Figures 20, 21a, and 21b.

\*Due to reporting limitations during the prototype testing phase, all teacher PD On Demand access was included when considering impact on student growth. Therefore, all of a teacher's PD module completion is counted in the analysis, regardless of whether a teacher accessed PD modules via the Insight Dashboard or Moodle. Future study will disaggregate the data according to those access methods in order to determine whether one has more impact on student growth and proficiency.

#### HOW TEACHER USAGE CORRELATED WITH STUDENT GROWTH IN GRADES 3, 4, AND 5

DreamBox is a personalized, adaptive program in which students in a single class may be learning concepts below, at, or above grade level. Therefore in addition to the data in Figure 1 showing proficiency growth for concepts at students' grade level, the data were also analyzed to determine the impact on student growth for math concepts below and above grade level. The analysis suggests that student proficiency growth for below-grade-level concepts was higher—as with concepts at grade level—when teachers completed more PD On Demand modules. Figure 9 shows that student growth in math topics from prior grade levels was between 33 to 52 percent higher than the growth of students whose teacher did not engage in any PD On Demand sessions.

The data in Figure 9 are discussed more fully in Appendix C and specifically Table 4.

The research suggests that student proficiency growth for below-grade-level concepts was higher as with concepts at grade level—when teachers completed more PD On Demand modules.







As seen in Appendix C, Table 4, the growth of students working on math concepts above their grade level was not significantly different. This result might be evidence that teachers do not spend their limited PD time to support students who are already proficient at their grade level.

Though school accountability measures are rigidly focused on specific outcomes based on a student's age, teachers and administrators are committed to providing differentiated learning support for students. The PD prototype enabled teachers to learn more about math concepts from any grade level in order to support students in need of intervention or acceleration. Therefore, another analyses of teacher prototype use focused on how teacher access to PD On Demand modules at different grade levels impacted student growth at their current grade level. As seen in Figure 10, students demonstrated as much as 60 percent more growth in mathematics achievement at their grade level when they had teachers who accessed PD modules at both their grade level and other grade levels.



## Increased growth for students whose teachers engaged in DreamBox PD modules for concepts both on grade and at other grades

Figure 10. Relationship between the grade level of teacher PD On Demand modules and student growth on grade level in DreamBox

Data for whether these other grade level modules were below or above grade level were not available. This analysis and data are described more fully in Appendix C and specifically Table 5.

These initial findings are promising because they indicate that teacher use of just-in-time, math-specific PD correlated with improved student achievement both at and below grade level. As discussed extensively in Appendix C, at all grade levels these correlations suggest that a teacher's use of DreamBox's PD On Demand modules may support student achievement on their end-of-year tests as well as have a "catch-up" effect for students who have gaps in understanding from prior grade levels. Improving content knowledge and applying it in the classroom needs ongoing support in order for positive changes in practice to take place.

KEY FINDING The DreamBox PD On Demand prototype provides a self-paced experience so that teachers can use real-time student data to engage in relevant professional learning.

## Looking Forward: Empowering Educators to Improve Student Outcomes using Transformative, Personalized, and Relevant Learning Experiences

Just as DreamBox Learning pioneered intelligent adaptive learning designed to delight K–8 students as they learn mathematics, DreamBox Learning's professional learning prototype was designed to delight teachers as they improve their understanding of mathematics concepts and their mathematical knowledge for teaching, so they can improve student achievement. At the core of this PD prototype design is a DreamBox Learning belief that both students and teachers are learners who deserve next-generation learning experiences that are transformative, personalized, and relevant.

Some elementary teachers struggle with mathematics knowledge, and thus have low self-images of themselves as mathematicians. They need and deserve a safe place to meaningfully engage and learn, which is why this prototype environment enables teachers to access relevant PD courses through their dashboards during a time they choose (after school, at home, during a PLC meeting, or within classroom time). They can review PD modules during their instructional planning time and use the modules to help guide their instruction and leverage research-based pedagogy.

Many schools and districts lack highly qualified teachers who have a strong mathematical knowledge for teaching. Even as teachers continually improve, actual change in practice takes time. Improving content knowledge and applying it in the classroom needs ongoing support in order for positive changes in practice to take place. DreamBox PD On Demand and this prototype environment help administrators and teachers support improved teacher understanding while ensuring relevance to what students are learning in their own personalized learning pathways.

The prototype environment described in this paper engages teachers in a dynamic, selfpaced experience that enables them to use their students' real-time performance data as a starting point for focusing their own professional learning, deepening their content knowledge, and informing their classroom curriculum and lessons. Because teachers' own professional learning pathways can be informed by their students' current demonstrated learning needs, teachers are able to further their learning of math concepts in a just-in-time model of teacher professional learning rather than a just-in-case model of one-size-fits-all PD. By experiencing this environment that alerts and informs them about their students' needs and enables them to deepen their own mathematical knowledge for teaching, the PD prototype is one step toward a new kind of experience that can immerse teachers in new models of professional learning that are personalized and competency-based.

#### APPENDIX A: BEST PRACTICES FOR STUDENTS AND PROFESSIONAL LEARNING

Like all new technologies and educational innovations, this prototype does not exist in a vacuum. Even though it was designed to support the very real and urgent needs of teachers and administrators, it needed to align with research-based principles and best practices of professional learning. All educators, content publishers, and edtech developers should be sure to understand the research, history, and best practices of the programs they're developing. There are four specific strategies and initiatives that are relevant to understanding the underlying design principles of this prototype:

- 1. Professional Learning Communities (PLCs)
- 2. Differentiated Instruction (DI)
- 3. Blended Learning (BL)
- 4. Mathematical Knowledge for Teaching (MKT)

By briefly defining these practices and their underlying principles, educators will better understand how this PD prototype integrates within the current context of professional learning in schools and districts.

#### PROFESSIONAL LEARNING COMMUNITIES: USING DATA TO INFORM CLASSROOM PRACTICE

One widely used strategy employed in schools is the PLC, introduced in 1997 by Shirley M. Hord and popularized by Richard and Rebecca DuFour, Robert Eaker, and many others.<sup>14</sup> Schools using PLC models focus on defining and assessing key learning outcomes and then using the data to make appropriate decisions for each student based on how well they achieved the goals. Thus, from the very beginning, regular access to reliable student achievement data was a necessity for PLCs.

These data weren't used simply to support student learning; they were also used to support adult learning and develop organizational capacity for continuous learning. As Hord noted from research conducted by Louis and Kruse and published in *Professionalism and Community: Perspectives on Reforming Urban Schools*:

"Acquiring and applying new knowledge is an intellectual task and a high priority in a professional learning community. Leaders in the most successful schools actively supported a culture of inquiry through constant scanning and bringing in of new ideas and people to help teachers reflect on their teaching practice and to develop increased skills. Leaders championed the need for information and data so that staff engaged in discussions of "What is working and how do we know?"<sup>15</sup>

15. Hord, S. M., "Professional learning communities...", p 43.

Schools using PLC models focus on defining and assessing key learning outcomes and then using the data to make appropriate decisions for each student based on how well they achieved the goals.

<sup>14.</sup> Hord, S. M., "Professional learning communities: Communities of continuous inquiry and improvement", Southwest Educational Development Laboratory, 1997.

#### DIFFERENTIATED INSTRUCTION: ADDRESSING LEARNER VARIATION

Because one teacher can't reasonably be expected to differentiate for every student every day, many educators have incorporated technology into their schools and classrooms as a way to help overcome the challenges of data collection, data use, and resource access. In addition to PLCs, another related initiative began gaining traction with the 1999 publication of Carol Ann Tomlinson's *The Differentiated Classroom: Responding to the Needs of All Learners*.<sup>16</sup> Schools began more formally training teachers in DI and related classroom practices in part because Tomlinson presented practical suggestions for how to implement principles that had been validated by research. For example, in the seminal book *How People Learn* published in 2000, an idea underlying DI was described as follows: "pay close attention to the individual progress of each student and devise tasks that are appropriate," and "present students with 'just manageable difficulties'—that is, challenging enough to maintain engagement, but not so difficult as to lead to discouragement."<sup>17</sup> Differentiation is not only a research-proven approach to improving each student's cognition, it's also one aspect of the personalized and individualized learning that parents now expect schools to provide for their children.

There are many challenges facing classroom teachers who are working to implement differentiated instruction. For example, educators need supportive, data-informed, responsive school structures, like a PLC, that provide time for differentiation. Educators also need quick access to actionable data that can inform classroom practice, and a reliable library of resources that can be used to engage students with "just manageable difficulties" in classroom lessons and small group work. Because one teacher can't reasonably be expected to differentiate for every student every day, many educators have incorporated technology into their schools and classrooms as a way to help overcome the challenges of data collection, data use, and resource access.

#### **BLENDED LEARNING: LEVERAGING TECHNOLOGY**

In 2001, Jennifer Hofmann was one of the first to coin the term *blended learning* to describe how technology could be used in conjunction with face-to-face learning. She noted, "the idea behind BL is that instructional designers review a learning program, chunk it into modules, and determine the best medium [i.e., online or face-to-face] to deliver those modules to the learner."<sup>18</sup> In the mid-2000s, discussion of BL rightly focused on pedagogy as well as medium, and educators discussed whether digital interactions improved the quality of pedagogy in addition to considerations of access and cost-effectiveness.<sup>19</sup> Despite the initial focus on pedagogy regardless of technology integration,<sup>20</sup> a more general definition of BL as a way of exclusively describing the medium without respect to pedagogy took hold in 2012 when it

<sup>16.</sup> Tomlinson, C. A., "The Differentiated Classroom: Responding to the Needs of All Learners", ASCD, 1999.

<sup>17.</sup> Bransford, J. D., Brown, A. L., & Cocking, R. R., "How people learn: Brain, mind, experience, and school (2nd ed.)", National Academy Press, 2000, p. 24.

Hofmann, J., "Blended Learning Case Study", 2001. Retrieved March 16, 2017 from: https://web.archive.org/ web/20010428074952/http://www.learningcircuits.org/2001/apr2001/hofmann.html.

<sup>19.</sup> Lee, J. E., "Design of blended training for transfer" (doctoral dissertation), Indiana University, 2007.

<sup>20.</sup> Whitelock, D. & Jelfs, A., "Journal of Educational Media Special Issue on Blended Learning", Journal of Educational Media, 2003.

was popularized by Heather Staker and Michael Horn:

"Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home."<sup>21</sup>

Coinciding with the evolution of PLCs and DI at the turn of the millennium, the rapid advancement of technology enabled BL approaches to also evolve in ways that had not previously been possible. While PLATO, LOGO, and other computer-based programs had been used in classrooms for many years, advancements in Internet connectivity, Flash, and HTML 4.0 provided opportunities to develop new learning experiences and expand global connections. For context, consider that the first Apple laptop with an option to be WiFienabled was the iBook released in 1999.<sup>21</sup> In addition, Wikipedia was launched in 2001, YouTube went live in 2005, and DreamBox Learning was conceived in 2006 when research and development of their K–2 math program began.

Whether defined by medium or by pedagogy, the concept of BL complemented the ideas of PLCs and DI, and was another strategy for meeting the needs of all students and improving achievement in mathematics. Yet access to these ideas and their associated resources alone can never be enough to equip teachers to improve the math achievement of all students. Another key strategy for improving student achievement in mathematics is the ongoing development and support of one of the most fundamental components of teacher capacity: mathematics content knowledge.

#### MATHEMATICAL KNOWLEDGE FOR TEACHING: DEEPENING MATH UNDERSTANDING

While the principles outlined for the prior three professional learning initiatives and incorporated into the prototype design can apply to all content areas, this PD prototype was constructed to specifically support educators' understanding of mathematics. The particular topics recommended to teachers are intended to ensure they deepen their mathematics content knowledge in specific ways.

21. Staker, H. & Horn, M, "Classifying K–12 blended learning", Innosight Institute, 2012, p 3.

22. "A brief history of Wi-Fi", The Economist Technology Quarterly, June 10, 2004. Retrieved March 16, 2017 from http://www.economist.com/node/2724397 Another key strategy for improving student achievement in mathematics is the ongoing development and support of one of the most fundamental components of teacher capacity: mathematics content knowledge. Given the importance of elementary teachers' understanding of relevant mathematics content and the limited pre-service mathematics coursework most elementary teachers complete, the importance of mathematics in-service professional learning cannot be overstated. Even before the National Council of Teachers of Mathematics (NCTM) published *Professional Standards for Teaching Mathematics* in 1991, which included "Knowledge of Mathematics" as one of six standards of professional development,<sup>23</sup> it stood to reason that teachers of mathematics should have a solid knowledge of mathematics content and processes. In 1999, around the same time that PLCs and DI were beginning to expand their reach, Liping Ma authored *Knowing and Teaching Elementary Mathematics*, in which she compared the mathematics knowledge of teachers in China and the United States. She described the complexity of mathematics content even at the elementary level as follows: "In the United States, it is widely accepted that elementary mathematics is 'basic,' superficial, and commonly understood ... Elementary mathematics is not superficial at all, and any one who teaches it has to study it hard in order to understand it in a comprehensive way."<sup>24</sup> Adding another perspective on the subject of Ma's work, Deborah Loewenberg Ball, Heather Hill, and Hyman Bass expanded the conversation beyond mathematics content knowledge to what they call "mathematical knowledge for teaching." One way they draw the distinction between mathematical knowledge for teaching and mathematical content knowledge is:

"Mathematical procedures that are automatic for adults are far from obvious to students; distinguishing between everyday and technical uses of terms—mean, similar, even, rational, line, volume—complicates communication. Although polished mathematical knowledge is an elegant and well-structured domain, the mathematical knowledge held and expressed by students is often incomplete and difficult to understand. Others can avoid dealing with this emergent mathematics, but teachers are in the unique position of having to professionally scrutinize, interpret, correct, and extend this knowledge … The teacher has to think from the learner's perspective and to consider what it takes to understand a mathematical idea for someone seeing it for the first time."<sup>25</sup>

Their research tested the hypothesis that the professional knowledge of mathematics that elementary teachers possess is of a different nature than other professions such as accounting or engineering, and they found that "teachers who scored higher on our measures of mathematical knowledge for teaching produced better gains in student achievement." Given the importance of elementary teachers' understanding of relevant mathematics content and the limited pre-service mathematics coursework most elementary teachers complete, the importance of mathematics in-service professional learning cannot be overstated.

25. Deborah Loewenberg Ball, Heather C. Hill, Hyman Bass, "Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide?", American Educator, Fall 2005, p.17.

<sup>23.</sup> National Council of Teachers of Mathematics (NCTM), "Professional standards for teaching mathematics", NCTM, 1991.

<sup>24.</sup> Ma, L., "Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States", Lawrence Erlbaum Associates, 1999, p. 146.

# APPENDIX B: DETAILED DESCRIPTION OF A PROFESSIONAL LEARNING PROTOTYPE FOR MATHEMATICS

The three individual components of DreamBox Learning—DreamBox Learning K–8 Math program for students, DreamBox Insight Dashboard for teachers, and DreamBox PD On Demand modules for teachers—are described in more detail in this Appendix.

#### STUDENT EXPERIENCE: DREAMBOX LEARNING K-8 MATH

The student component of the prototype is the <u>DreamBox Learning K–8 Math</u> program, which is accessible in either English or Spanish from any Internet-connected desktop, laptop, or iPad. DreamBox is a self-directed digital curriculum that leverages an Intelligent Adaptive Learning<sup>™</sup> engine and innovative virtual manipulatives to assess student thinking and proficiency in mathematics, and then differentiates uniquely for students in real time. As students choose their own lessons along coherent learning pathways, DreamBox's underlying assessment platform collects rich data about not only student answers but also student strategies. Students typically use DreamBox two or three times a week for between twenty and thirty minutes per session. Information about research evaluations, case studies, and implementation models is available at dreambox.com/research.

Whether students are learning concepts that are below, at, or above their assigned grade level, DreamBox automatically uses all data both formatively and summatively to adapt and differentiate for students both within and between lessons. Examples of real-time differentiation include varying the number or types of problems a student encounters, and providing just-in-time scaffolding and feedback tailored specifically to the types of mistakes a student makes. DreamBox lessons aren't merely digitized versions of analog tools and plastic manipulatives that have traditionally been used in classrooms; they engage students in mathematical tasks with manipulatives that can only exist in a digital environment. Two examples are shown in Figures 11 and 12, and more examples can be seen at either <u>dreambox.com/teachertools</u> or <u>dreambox.com/videos</u>. As students choose their own lessons along coherent learning pathways, DreamBox's underlying assessment platform collects rich data about not only student answers but also student strategies.



The DreamBox curriculum is thus a complement to face-to-face math courses, as DreamBox enables students to explore and make sense of math concepts in ways that aren't possible without technology. Access to curriculum from earlier or later grade levels ensures that students aren't frustrated or bored with topics at their defined grade level. As a digital curriculum that enables students to have some element of choice over time, place, path, and pace, DreamBox Learning K–8 Math supports both DI and BL initiatives.



Figure 11. DreamBox Open Array (<u>dreambox.com/teachertools</u>)



Figure 12. DreamBox Scaling Number Line (dreambox.com/teachertools)

#### EDUCATOR EXPERIENCE: DREAMBOX INSIGHT DASHBOARD

The educator component of the prototype is the <u>DreamBox Educator Insight Dashboard</u>, which is how teachers and administrators access the student data collected as students engage with DreamBox Learning K–8 Math. The Insight Dashboard provides daily updates and data visualizations so that teachers can easily monitor and respond to student growth and proficiency aligned with their regional standards, including Common Core, Texas Essential Knowledge and Skills (TEKS), and others (Figure 13).



Figure 13. Class proficiency grid by standard

In addition to the personalized lesson recommendations DreamBox presents to students, teachers have the ability to leverage specific portions of the DreamBox curriculum by making either short-term or long-term assignments aligned with a particular topic or standard. These assigned lessons appear for students with specific icons so that students can distinguish them from the other lessons (Figure 14). When a teacher creates an assignment, DreamBox's adaptive engine will automatically differentiate that assignment for each student based on whether they have encountered or completed lessons on that assigned topic in the DreamBox curriculum.



Figure 14. Student DreamBox lesson selection screen for Grades 3–5

DreamBox also provides information that teachers can use to make strategy groups or plan upcoming lessons based on which students have demonstrated proficiency for a specific standard (Figure 15).

Because there are millions of self-directed, coherent, personalized learning pathways that students can choose from, DreamBox also provides a real-time activity feed that shows what individual students are learning and how well they're doing, and that provides educators an opportunity to access the same lesson the student is working on (Figure 16).

These combined features enable the DreamBox Educator Insight Dashboard to help teachers implementing PLC, DI, and BL programs.

Leports MyFlexPD Resources Settings					
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Bedford 3rd-5th Math Class (WA) GRADE 4 CLASSBOOM - DREAMBOX ACCESS Add New Assignment	5 RESOURCES - INDIANA ACADEM	IC STANDARDS FOR MATHEMATICS			
Assignment Types			Assignment Duration		
Short-Term: Student receives 1 or 2 personalized	I lessons on the selected topic.		2 weeks		~
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×	×		Торіс		Standard
			Grade 5		~
Long-Term: Personalized lessons will be available	le every day until the student ar	hieves proficiency on the topic	Fractions & Decimals		~
or until the end of the specified number of weeks	s		Multiplying Decimals with Arrays		~
Multiplying Decimals with Arrays Students multiply decimal numbers up to the thousa Preview Lessons: Just Started Lesson In-Pro	ndīhs place using an array as a gress Lesson Review Lesso	model.			Start: 6/26/2017 > Due: 7/10/2017
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Soseph Q (3rd) Karen Z (5th) Lise V (4th) Mergeret R (3rd)	E E E			Helen D (Str)	(E)

Figure 15. Creating differentiated assignments based on student proficiency

Because there are millions of self-directed, coherent, personalized learning pathways that students can choose from, DreamBox also provides a real-time activity feed that shows what individual students are learning and how well they're doing, and that provides educators an opportunity to access the same lesson the student is working on (Figure 16).



Figure 16. Student lesson activity feed

These combined features enable the DreamBox Educator Insight Dashboard to help teachers implementing PLC, DI, and BL programs.

#### EDUCATOR EXPERIENCE: DREAMBOX PD ON DEMAND MODULES

The professional development component used in the prototype is called DreamBox PD On Demand, a competency-based professional learning environment that uses short instructional videos, sample DreamBox student lessons, and brief quizzes to help educators understand the mathematics concepts that underlie the DreamBox Learning K–8 Math curriculum. Professional learning modules are organized by core elementary math topics such as Number Sense, Addition and Subtraction, and Multiplication and Division. A portion of the Table of Contents for the PD On Demand modules on the Educator Insight Dashboard is shown in Figure 17.

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NUMBER SENSE, ADDITION, AND SUBTRACTION	28 Lessons 🔺	with no connection
Lessons		to student data
Investigation 1: Kindergarten – Counting, Lesson 1 – Build 1-10 Optimally	Not viewed PD	
Investigation 1: Kindergarten - Counting, Lesson 2 - Doubles and Near Doubles	Not viewed PD	
Investigation 2: First Grade - Counting, Lesson 1 - Build to 20 Optimally	Not viewed PD	
Investigation 2: First Grade - Counting, Lesson 2 - Build to 100 Optimally	Not viewed PD	
Investigation 1: Kindergarten - Comparing and Ordering, Lesson 1 - Compare 1-10	Not viewed PD	
Investigation 1: Kindergarten - Comparing and Ordering, Lesson 2 - Identify More, Less and Equal	Not viewed PD	
Investigation 2: First Grade - Comparing and Ordering, Lesson 1 - Identify More and Less up to 100	Not viewed PD	
Investigation 2: First Grade - Comparing and Ordering, Lesson 2 - Counting Forward and Backward	Not viewed PD	
Investigation 2: First Grade - Comparing and Ordering, Lesson 3 - Building Columns of a Hundreds Chart	Not viewed PD	
Investigation 3: Second Grade - Comparing and Ordering, Lesson 1 - Finding Equal Expressions	Not viewed PD	
Investigation 3: Second Grade - Comparing and Ordering, Lesson 2 - Hundreds Charts to 500	Not viewed PD	
Investigation 1: Kindergarten - Addition and Subtraction, Lesson 1 - Identify Missing Addend	Not viewed PD	
Investigation 1: Kindergarten - Addition and Subtraction, Lesson 2 - Beginning Adding and Removing	Not viewed PD	
Investigation 1: Kindergarten - Addition and Subtraction, Lesson 3 - Identify Number Pairs	Not viewed PD	
Investigation 2: First Grade - Addition and Subtraction, Lesson 1 - Doubling and Making 10	Not viewed PD	

Figure 17. PD On Demand table of contents on the educator Insight Dashboard

Figure 18 shows an example of an early lesson in a PD On Demand module for multiplication and division, including the video learning component, vocabulary, and links to studentfacing lessons.





PD On Demand helps teachers understand the big ideas, strategies, and models related to these math topics as well as students' cognitive development in these areas. DreamBox's PD On Demand and student curriculum are informed by research-based developmental trajectories, including Cathy Fosnot's *Landscapes of Learning*.<sup>26</sup> These landscapes help educators understand how math concepts are related to student development by representing mathematical progressions as non-linear journeys from initial conceptions (the bottom of the landscape) through deep understanding and expertise (the top of the landscape).

The lower half of Fosnot's Landscape for Multiplication and Division is shown in Figure 19, where the initial student strategies for working with multiplication are using contexts of equal groups and skip counting. As students build on those initial strategies for multiplying, they encounter big ideas such as the distributive property and unitizing, and use other strategies such as doubling and partial products.



The landscape of learning: multiplication and division on the horizon showing landmark strategies (rectangles), big ideas (ovals), and models (triangles).

#### Figure 19. Portion of the Landscape of Learning for Multiplication & Division

*From Investigating Multiplication and Division,* Grades 3-5, in the *Contexts for Learning Mathematics* series by Catherine Twomey Fosnot. Copyright (c) 2007 by Catherine Twomey Fosnot. Published by Heinemann, Portsmouth, NH. Reprinted by permission of the Publisher.

While learning how these mathematical concepts and skills are connected in developmental pathways, teachers also engage with the student versions of DreamBox's digital manipulatives and games. Therefore, the PD On Demand modules align with one of the goals outlined by Ball and colleagues: "the teacher has to think from the learner's perspective and to consider what it takes to understand a mathematical idea for someone seeing it for the first time."<sup>27</sup>

#### APPENDIX C: RESEARCH QUESTIONS, METHODOLOGY, AND TECHNICAL REPORTS RESEARCH QUESTIONS

There are two primary research questions driving the consideration of the data and continued investigation of professional learning prototype environments such as the one described in this paper:

- 1. To what extent do teachers deepen their understanding of math by accessing dynamic, web-based professional learning resources that are aligned with their students' needs and their classroom curriculum?
- 2. To what extent does this PD prototype environment enable teachers and administrators to use real-time student performance information and alerts to make more personalized professional learning choices?

During this project, not enough data were collected to conclusively answer either research question. The data collected provide more insight about question two than question one. Because the early testing and analysis didn't include any direct assessment of teachers' mathematical improvement, no conclusions were drawn about question one.

Properly answering question one would require assessing the change in teachers' content knowledge both before and after substantially interacting with the PD prototype environment. Because there was neither control for initial teacher conditions nor evaluations of the change in teachers' mathematics knowledge, there are too many confounding factors to draw any conclusions from these data about research question one. Therefore this analysis will center on answering question two.

#### **TEACHER USAGE STATISTICS**

One of the comparisons investigated was how teachers accessed PD On Demand modules. For all teachers who had access to the PD prototype environment, DreamBox PD On Demand was accessable via two methods: either selecting PD content from the Insight Dashboard links, or via direct login to the Moodle platform. A high level comparison of where the PD On Demand sessions originated is seen in Figure 20. Of the 1,490 total PD On Demand sessions during the analysis phase, 1,105 were initiated from the Insight Dashboard, compared to 385 sessions accessed directly via the Moodle platform. In 40 percent of the PD On Demand sessions initiated via Moodle, teachers accessed multiple PD On Demand modules during their session. This compares to only 18 percent of the PD On Demand sessions initiated via the Insight Dashboard in which teachers accessed multiple modules. It therefore appears possible that sessions initiated via the Dashboard were more exploratory in nature, whereas sessions initiated via Moodle were more likely intended for the purpose of professional development. One possible explanation for this difference is that the PD prototype was introduced midyear for most teachers, at a time when many of them were already in the middle of year-long professional learning plans that had been planned using the Moodle interface and were not necessarily focused on real-time student data from DreamBox.



#### **Discrete Sessions**



As seen in Figures 21a and 21b, rates of teacher engagement with the PD prototype environment were between 20 and 40 unique teachers per week during the first phase of the study. In January of 2017, additional teachers were given access to the prototype, resulting in substantially higher usage following the winter break. Weekly usage via direct Moodle login was not common during the initial phase of the study; however, the number of direct logins increased with later groups of teachers. \*During the prototype testing phase, data collection systems did not enable disaggregation to determine which of the three primary PD On Demand link locations were most frequently used to access PD On Demand from the Insight Dashboard. Future study of these entry points to the PD On Demand would yield interesting findings and provide more insight into when and why teachers are seeking to more deeply understand specific math concepts. Given the unique nature of the PD Prototype and the relatively short time span of the early testing period, it is difficult to draw conclusions about these types of access. In some instances, schools and teachers already had plans for using PD On Demand modules to support broader PD initiatives, and, as noted earlier, in those cases their original plans with the Moodle platform were more relevant than the links to student data.

\* Areas of further study.





Figure 21a. Cumulative PD prototype sessions and unique teachers by access method

Weekly PD On Demand usage



Figure 21b. Weekly PD On Demand sessions and new and returning teachers by access method

#### ASSOCIATION WITH STUDENT IMPACT

The primary focus of the project was teacher usage in Grades 3–5. The findings of data collected for that group of 649 teachers are reported here. Teacher selection was not randomized, and there are other complexities in the data, including the multi-level nested design of districts-schools-teachers-students as well as the voluntary selection into actual participation in PD On Demand sessions. Therefore it is difficult to model the impact of teacher engagement with PD On Demand on student learning in a way that suggests causal links. In order to appropriately conduct the analyses, two primary analyses were completed separately for Grades 3, 4, and 5. For the purposes of these analyses, student growth is measured according to progress and proficiency in the DreamBox curriculum. And, all teacher PD On Demand access is considered, regardless of whether they entered the PD modules via the Insight Dashboard or the Moodle platform. Discussion and analyses drawn from the data presented here appear in the next section.

For each grade level, the first analysis examined the amount of growth in student proficiency not only for concepts at their current grade level, but also for concepts in the grade levels immediately below and above their grade. For example, for the set of Grade 4 students, the analysis considered the growth in student proficiency for mathematics concepts at the Grade 3 level, the Grade 4 level, and the Grade 5 level.

By using this approach, it was possible to determine whether teacher usage of PD On Demand had an effect on student learning for concepts students were currently being taught, as well as for concepts that they should (but may not) have mastered the previous year, and for concepts they may not be introduced to until the next grade level. These growth levels were then evaluated separately for three groups of teachers:

- 1. Teachers who never accessed PD On Demand
- 2. Teachers who engaged in only one or two sessions of PD On Demand
- 3. Teachers who engaged in three or more sessions of PD On Demand

These three groups were selected because they provided the best balance of interpretability by differentiating between teachers who did not complete PD On Demand, those who briefly explored it, and those who engaged in it regularly. These comparisons, therefore, provide a broader view of the potential impact of PD On Demand on multiple aspects of self-directed teacher learning and differentiated student learning.

The second analysis examined the amount of growth in student proficiency in concepts at their current grade level only for students at each grade level. This growth was then compared between teachers with different usage of PD On Demand. Specifically, teachers had the option to choose which modules they wanted to pursue, and there were no restrictions that limited teachers to selecting content that was relevant only to their current grade level. For example, a Grade 4 teacher could choose to engage in curriculum related to Grade 4 concepts, but they could also choose to engage in curriculum related to Grade 3 concepts as well.

The freedom to choose modules at any grade level resulted in four distinct groups of teachers who accessed DreamBox PD On Demand:

- 1. Teachers who did not complete any modules
- 2. Teachers who completed modules relevant only to their own grade level
- 3. Teachers who completed modules relevant to their own grade level and modules relevant to other grade levels
- 4. Teachers who completed modules relevant to other grade levels, but no modules relevant to their own grade level

These groupings and comparisons provide a broad view of the potential impact of different aspects of the PD On Demand modules on a specific aspect of student learning. Whereas the first set of analyses examined how students improved over a range of mathematics topics, the second set of analyses were focused specifically on the content that they were expected to master during the academic year. \*While it would have been interesting to conduct analyses similar to these for teachers who engage in modules below or above the level of their class to determine the specific impact on student performance on topics they either should have already mastered or that they are not expected to master until next year, sample sizes were insufficient to complete such an investigation due to the uncontrolled nature of the study design.

The results for the first set of analyses are presented in Table 4. As discussed in subsequent sections, the data clearly show considerable differences in student proficiency growth associated with teacher use of PD On Demand modules. Likewise, general results for the second set of analyses are presented in Table 5.

	Proficiency Growth by Grade Level	Numbe 0	er of PD Se 1 to 2	essions 3+
	Grade 2	13.5	13.8	20.5
GRADE 3	Grade 3	18.7	21.6	25.4
STODERTS	Grade 4	19.9	19.4	22.1
	Grade 3	12.5	15.2	16.6
GRADE 4	Grade 4	12.1	16.6	18.1
STODERTS	Grade 5	11.2	13.1	11.6
	Grade 4	9.1	10.7	13.3
GRADE 5	Grade 5	9.5	12.0	12.5
STODENTS	Grade 6	8.0	8.5	6.1

Table 4. Mean student proficiency growth by teacher PD On Demand usageNote: means in a single row with different colors are significantly different

	No PD	At Grade Level + Other Grades	At Grade Level Only	At Other Grades Only
Grade 3	18.7	23.9	20.0	22.5
Grade 4	12.1	19.4	19.6	15.7
Grade 5	9.5	13.5	8.3	12.1

 Table 5. Mean student proficiency growth by teacher PD On Demand usage type

 Note: means in a single row with different colors are significantly different

#### **GRADE 3 STUDENTS**

Results for Grade 3 are shown in Figures 22a and 22b. Figure 22a clearly shows that for topics below the Grade 3 level (i.e., Grade 2 concepts for Grade 3 students, represented by the set of three bars on the left side of the figure), teacher PD On Demand usage on three or more occasions was significantly associated with greater student improvement in those prior-grade concepts. In this chart, n represents the number of students who demonstrated measurable learning progress and proficiency on math concepts at the stated grade level in the DreamBox curriculum. For this analysis, student progress and proficiency was measured by a proprietary metric within DreamBox's internal assessment system that for the purposes of this white paper will be referred to as "growth points." For example, the bar on the far left of Figure 22a should be interpreted as follows: There were 13,905 third-grade students who not only showed measurable growth in proficiency for second-grade concepts but also had a third-grade teacher who never engaged in any PD On Demand sessions. During the analysis window, these 13,905 students proficiently improved an average of 13.5 growth points as related to the second-grade concepts in the DreamBox curriculum.

Within that same set of bars in Figure 22a, that finding needs to be compared to the bar on the right, where n = 533. That bar shows that the 533 Grade 3 students whose teachers engaged in three or more sessions of PD On Demand proficiently progressed an average of 20.5 growth points related to Grade 2 concepts in the DreamBox curriculum. This correlation is important because it demonstrates that a teacher's usage of PD On Demand may have a catch-up effect for students in their classroom, which helped them reach greater levels of proficiency on topics that they should have previously learned.



#### Average increase in proficiency, Grade 3

Similarly, for same-grade-level concepts, teacher PD On Demand usage was significantly associated with greater improvement in student proficiency, as represented by the middle set of bars in Figure 22a. This correlation indicates that teachers who engaged in modules had students who showed greater growth in proficiency of grade-level concepts, with greater frequency of PD On Demand usage associated with greater growth overall. Among the 5,684 Grade 3 students whose teachers never used PD On Demand, average growth in proficiency for Grade 3 concepts was 18.7 growth points, which was lower than the average proficiency growth for the 1,068 Grade 3 students whose teachers completed one or two PD On Demand sessions, and the 218 Grade 3 students whose teachers engaged in three or more sessions. These groups proficiently progressed an average of 21.6 and 25.4 growth points related to Grade 3 topics within the DreamBox curriculum, respectively. No differences were observed on Grade 5 curriculum.

Figure 22a. Growth for Grades 2, 3, and 4 mathematics concepts Note: All differences at Grade 3 and the differences for 3+ sessions at Grade 2 are statistically significant, p < .001

Figure 22b shows the impact of the relative grade level of teacher-selected PD On Demand modules on student proficiency, yielding an interesting pattern. Specifically, significant growth was observed in students whose teachers used it for Grade 3 modules in addition to modules relevant to other grades. Stated differently, growth in student proficiency was highest among teachers who accessed a range of modules across grade levels, and not simply the content relevant to Grade 3. This difference in average growth can be seen, given the 5,684 students whose teachers engaged in no PD On Demand sessions and the 327 students whose teachers engaged only in Grade 3 modules had an average proficiency growth of 18.7 and 20.0 growth points, respectively. By contrast, the 378 students whose teachers completed modules for Grade 3 and other grade levels, and the 581 students whose teachers completed only other grade material, had growth of 23.9 and 22.5 growth points, respectively.



#### Average increase in proficiency, Grade 3

Figure 22b. Grade 3 student growth for Grade 3 mathematics concepts Note: Means for "PD: Grade 3 + Other Grades" and "PD: Other grades only" are significantly greater than means for "No PD Completed" and "PD: Grade 3 Only," *ps* < .001

#### **GRADE 4 STUDENTS**

Results for Grade 4 are shown in Figures 23a and 23b. Figure 23a clearly shows that for topics below grade level (i.e., Grade 3 concepts for Grade 4 students, represented by the set of three bars on the left side of the figure), teacher PD On Demand usage was associated with greater student improvement in those prior-grade concepts, and the amount of growth in proficiency was associated with the frequency of usage.



#### Average Increase in Proficiency, Grade 4



Among Grade 4 students who not only had measurable proficiency growth in Grade 3 concepts but also had teachers who engaged in no PD On Demand, proficiency progressed an average of 12.5 growth points related to Grade 3 concepts in the DreamBox curriculum during the analysis window. This growth is compared to the Grade 4 students whose teachers engaged in one or two sessions of PD On Demand or in three or more sessions of PD On Demand. These groups proficiently progressed an average of 15.2 and 16.6 growth points related to the DreamBox Grade 3 curriculum, respectively.

This relationship is similar to what was seen in the Grade 3 analysis, and again illustrates that a teacher's usage of PD On Demand may have a catch-up effect for students in that classroom, thereby helping them achieve greater levels of proficiency on topics that they should have previously learned. Likewise, for same-grade-level concepts, teacher usage was associated with greater improvement in student proficiency, and greater levels of growth were associated with more frequent usage, as represented by the middle set of bars in the figure. Teachers who engaged in PD On Demand modules had students who showed greater growth in proficiency of grade-level concepts. Among the Grade 4 students whose teachers did not engage with PD On Demand, the average growth in proficiency for Grade 4 topics was 12.1 growth points, which was lower than the Grade 4 students whose teachers accessed one or two sessions and the Grade 4 students whose teachers engaged in three or more sessions. The average growth in proficiency of Grade 4 topics in the DreamBox curriculum for these groups was 16.6 and 18.1 growth points, respectively.



#### Average increase in proficiency, Grade 4

**Professional Development Activity** 

Figure 23b. Grade 4 student growth for Grade 4 mathematics concepts Note: Means for "PD: Grade 4 + Other Grades" and "PD: Grade 4 Only" are significantly greater than means for "No PD Completed" and "PD: Other Grades Only," *ps* < .001, and the mean for "PD: Other Grades Only" is significantly greater than the mean for "No PD Completed," *p* < .001 Figure 23b presents the impact of the grade level of PD On Demand modules on student proficiency. This analysis yielded a distinctly different pattern than what was observed with the Grade 3 students. Specifically, the greatest growth in student proficiency related to Grade 4 concepts was seen in students of teachers who used modules for Grade 4 concepts, regardless of whether those teachers also accessed modules for other grade levels. Stated differently, growth in student proficiency among Grade 4 students was highest in classrooms where teachers used Grade 4 PD On Demand modules. This difference in average growth can be seen, given the Grade 4 students whose teachers engaged only in other grade level modules had an average proficiency progress of 12.1 and 15.7 growth points. By contrast, the Grade 4 students whose teachers accessed both Grade 4 modules as well as modules for other grade level material, had growth of 19.6 and 19.4 growth points, respectively.

#### **GRADE 5 STUDENTS**

Results for Grade 5 are shown in Figures 24a and 24b. Figure 24a clearly shows that for topics below grade level (i.e., Grade 4 concepts for Grade 5 students, represented by the set of bars on the left side of the figure), teacher PD On Demand usage was associated with greater student improvement in prior-grade concepts.



#### Average increase in proficiency, Grade 5

Figure 24a. Grade 5 student growth for Grades 4, 5, and 6 mathematics concepts Note: Due all differences at grades four and differences between no PD and 1-2 and 3+ PD sessions in five are statistically significant, p < .001 Amongst the Grade 5 students whose teachers engaged in no PD On Demand, proficiency progressed an average of 9.1 growth points related to Grade 4 concepts in the DreamBox curriculum during the prototype testing window. This growth is compared to the Grade 5 students whose teachers engaged in only one or two sessions of PD On Demand, and the Grade 5 students whose teachers engaged in three or more sessions. These groups proficiently progressed an average of 10.7 and 13.3 growth points related to the DreamBox Grade 4 curriculum, respectively.

This trend is consistent with the trend seen for Grade 3 and Grade 4 students, and provides still more evidence that a teacher's usage of PD On Demand modules may have a catchup effect for the students in their classroom, thereby helping them reach greater levels of proficiency on topics that they should have previously learned. Likewise, for same-grade-level concepts, teacher usage was associated with greater improvement in student proficiency, as represented by the middle set of bars in Figure 24a. Teachers who engaged in PD On Demand had students who showed greater growth in proficiency of grade-level concepts. Among the Grade 5 students whose teachers did not engage with PD On Demand, the average growth in proficiency for Grade 5 topics was 9.5 growth points, which was lower than the Grade 5 students whose teachers accessed one or two sessions, and the Grade 5 students whose teachers accessed one or two sessions, and the Grade 5 students whose teachers in three or more sessions. The average growth in proficiency of Grade 5 topics in the DreamBox curriculum for these groups was 12.0 and 12.5 growth points, respectively.



#### Average increase in proficiency, Grade 5

Figure 24b. Grade 5 student growth for Grade 5 mathematics concepts Note: Means for "PD: Grade 5 + Other Grades" and "PD: Other grades Only" are significantly greater than means for "No PD Completed" and "PD: Grade 5 Only," *ps* < .001 Figure 24b presents a comparison of the impact of the grade levels of PD On Demand modules on student proficiency. This chart yields a pattern that is distinctly different from what was observed with the Grade 3 and Grade 4 students. Specifically, the significantly greater growth in student proficiency of Grade 5 concepts was seen in students of teachers who used PD On Demand for concepts other than Grade 5 topics; the access of Grade 5-specific modules did not appear to have a drastic impact on student performance. This difference in average growth can be seen, given that the Grade 5 students whose teachers engaged in no PD On Demand sessions and the students whose teachers engaged only in Grade 5 modules had an average proficiency growth of 9.5 and 8.3 growth points. By contrast, the Grade 5 students whose teachers completed modules for topics in Grade 5 and other grade levels, and the Grade 5 students whose teachers accessed only modules for other grade levels, had growth of 13.5 and 12.1 growth points, respectively. One plausible explanation for this finding is that the Grade 5 students as a whole demonstrated the most growth in proficiency in Grade 4 curriculum. As such, the PD On Demand modules may have played an especially important catch-up function for this group of students.



#### APPENDIX D: AREAS OF FURTHER STUDY 🛅

#### 1. Analyze student growth based on their teacher's understanding of mathematics

"As seen in Figure 1, across all Grades 3–5, students demonstrated over 30 percent more growth in mathematics proficiency at their grade level when they had teachers who more frequently accessed the PD modules. **These results warrant further study, as they could be a confirmation of the findings that teachers with a stronger mathematical knowledge for teaching have students with higher levels of achievement.**" (AREAS OF FURTHER STUDY P. 6)

#### 2. Analyze student growth based on why a teacher accesses PD

"Though it wasn't possible in this initial study, **future investigations will disaggregate the Insight Dashboard teacher access data by the three use cases mentioned earlier.** With those data, it will be possible to learn – for example – whether teachers were more likely to use the PD On Demand modules to understand the math concepts in their classroom-taught curriculum than they were to support individual students with intervention or acceleration support." (AREAS OF FURTHER STUDY P. 20)

"During the prototype testing phase, data collection systems did not enable disaggregation to determine which of the three primary PD On Demand link locations were most frequently used to access PD On Demand from the Insight Dashboard. **Future study of these entry points to the PD On Demand would yield interesting findings and provide more insight into when and why teachers are seeking to more deeply understand specific math concepts.**" (AREAS OF FURTHER STUDY P. 39)

## 3. Analyze student growth based on whether teachers use student data to choose PD topics

"Due to reporting limitations during the prototype testing phase, all teacher PD On Demand access was included when considering impact on student growth. Therefore, all of a teacher's PD module completion is counted in the analysis, regardless of whether a teacher accessed PD modules via the Insight Dashboard or Moodle. **Future study will disaggregate the data according to those access methods in order to determine whether one has more impact on student growth and proficiency.** (AREAS OF FURTHER STUDY P. 21)

#### 4. Analyze student growth based on the grade level of PD topics teachers choose

"While it would have been interesting to conduct analyses similar to these for teachers who engage in modules below or above the level of their class to determine the specific impact on student performance on topics they either should have already mastered or that they are not expected to master until next year, sample sizes were insufficient to complete such an investigation due to the uncontrolled nature of the study design." (AREAS OF FURTHER STUDY P. 42)

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#### **APPENDIX F: ABOUT THE AUTHORS**

#### TIM HUDSON, PhD

Dr. Tim Hudson is the vice president of learning at DreamBox Learning as well as a learning innovator and education leader who frequently writes and speaks about the intersection of learning, schooling, and technology. At DreamBox, Tim oversees the research and development of innovative learning experiences that engage students in mathematical thinking and provide teachers with useful information to support differentiation and personalization in their classrooms. He has spoken at national conferences such as ASCD, iNACOL, NCTM, and SXSWedu and, along with DreamBox advisor Cathy Fosnot, co-authored the chapter "Classrooms Where Children Learn" in an NCTM book about mathematics intervention. Prior to joining DreamBox, Tim spent more than 10 years working in public education, first as a high school mathematics teacher and then as a K–12 mathematics coordinator and strategic planning facilitator for the Parkway School District in suburban St. Louis, Missouri. Follow his conversations on Twitter @DocHudsonMath and on the DreamBox Learning blog.

#### DAN NEAL, PhD

Dr. Dan Neal is a research scientist and statistician with extensive experience in both academia and the private sector. As a faculty member, he taught undergraduate and graduate courses in research methods and advanced analytics. Dan was awarded multiple federal research grants, and has published over 25 peer-reviewed research articles. Upon leaving academia, he brought his unique scientific and statistical consulting background to such diverse fields as aerospace supply chains, cellular- and video-game network performance, and mathematical modeling of consumer behavior. Dan has served as manager and director of research and analytics teams of various sizes, and at DreamBox he is responsible for ongoing analysis of student teacher performance data.

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