i-Ready in 7th Grade Math Classes

A MIXED METHODS CASE STUDY

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INTRODUCTION

This study of i-Ready shows on average positive, but differential, gains for students who use the tool for varying amounts of time. In addition, the field-based observations we conducted clearly raise questions about the balance between the choice of specific edtech tools and the best practices for implementing them in schools. The quantitative and qualitative data collected in this study examine who is best served by the technology, in what ways, and under what circumstances.

Our quantitative analysis showed that students, regardless of their math proficiency, who spent a minimum of 45 minutes a week or more on the i-Ready lessons had a significant improvement in their scores on the Smarter Balanced Assessment Consortium Math Summative Assessment (SBAC)[1] over students who did not.

During the observations, it was noted that the product was challenging for less proficient students to use, which was later confirmed by our quantitative analysis — many students who used i-Ready consistently enough to see its benefits were already meeting or exceeding standards in mathematics on the SBAC.

To complicate matters, students were critical of i-Ready, even when they could see its merits. Most of these critiques reflected the students' opinions that by 7th grade, i-Ready was too childish for them and did not give them enough control over their learning. The students who expressed a preference for i-Ready often reported that it was because i-Ready was easier — indicating they might not be as confident in math as their peers who were more critical of i-Ready. This was confirmed by our observations of classes in which students could choose what math product they used — less proficient students gravitated toward i-Ready. The students who preferred i-Ready (despite agreeing with many of the critiques) also used it the least and received the least benefit. This indicates that perhaps the problem of reaching struggling students is not an i-Ready problem, but a systemic problem in edtech that bears more investigation.

I-Ready aims to be a product that supports the learning (not just practice) of math. However, no students reported

1 Throughout this paper, SBAC is used to refer to the Smarter Balanced Assessment Consortium Summative Assessment in Mathematics.

learning new concepts from i-Ready during our focus groups. They reported that their work on i-Ready reinforced concepts that had been introduced in class. At times the product was quite successful in this regard.

Teachers in our study expressed mixed views about the product — they described it as good for practice, for backfilling concepts that students were lacking, and for helping diagnose class-wide learning needs. But they all reported a mismatch between the mathematics knowledge they observed and what i-Ready reported for many of their students. They were often frustrated by a lack of transparency. Teachers described significant delays in reporting on student progress and diagnostic scoring.

Resolving all these contrasts is out of the scope of this opportunistic study of math edtech products in use in 7th grade classrooms, of which i-Ready was one among many. Rather, in the next pages we aim to paint a picture of how students and teachers engaged with and understood i-Ready — framed by the findings of our comparative analysis of i-Ready's impact on student achievement. Our hope is that from this description educators and product developers can glean insights into how to develop and implement products that reach all students equitably.

BACKGROUND

Early in the summer of 2017, the Silicon Valley Education Foundation's STEM Innovation Hub (iHub) team reached out to WestEd for support in developing their staff's evaluation capacity, to broaden their work with edtech product developers and schools. Together, WestEd researchers and iHub team members conceptualized a mixed methods study that would seek to discover what edtech products were in use in 7th grade mathematics classrooms and work to understand how teachers used these products, what students thought of them, and what impact they had on student achievement.

Students start to accelerate in math during middle school to reach calculus by 12th grade. Research shows that success in advanced math courses in high school predicts postsecondary success and careers in science, technology, engineering, and math (Adelman, 1999). A 2006 report from the U.S. Department of Education showed that students who completed coursework through precalculus were two times as likely to successfully complete college compared to students who only completed algebra 2 (Adelman, 2006).

Success in high school mathematics has been correlated with college success (Adelman, 2006). Given the importance of middle school mathematics performance for high school success (Adelman, 1999) and the flood of edtech products (Shulman, 2018), there is a need to understand how these products are being used in middle school. Focusing on 7th grade allowed the study to utilize prior-year middle school math data as part of the analysis.

Research Methods

With a goal of starting data collection in the fall, the team relied heavily on the Silicon Valley Education Foundation's (SVEF's) long-standing relationships with local districts to obtain research permissions and data agreements over the summer. By the end of October 2017, four months after the study was conceptualized, two districts had signed on to participate, agreeing to share student-level SBAC and product data for all their 7th grade students and to select teachers for participation in qualitative observations.

Meanwhile, three iHub team members received training from WestEd staff in qualitative data collection. While all were familiar with conducting rubric-driven classroom observations, the ethnographic stance necessary for evaluating a product in use was unknown to them. The team was introduced to the basic tenets of grounded theory (Charmaz, 2006; J. Corbin & Strauss, 2008), qualitative interviewing and question-asking techniques (Seidman, 2006), and observation note taking (Emerson, Fretz, & Shaw, 2011) by WestEd research staff. With the guidance of a WestEd senior researcher, these three iHub team members completed the qualitative data collection.

The point of the study was to understand how products were being used in real time — during school by students while they were in class. The hope was to observe two to four products in action and use those observations, as well as product data, to answer the research questions below. Our aim was not a comprehensive evaluation of a product and its full suite of capacities, nor did we seek to understand whether the product was aligned to state standards for mathematics. Rather, we opportunistically asked to observe lessons on days when teachers would be using edtech and then chose the most consistently used math products to focus on for our case studies.

Research Questions

1. Do we see any relationship between product use and student achievement as measured on the Smarter Balanced Assessment Consortium Summative Assessment in Mathematics?
2. What is the impact of i-Ready on student math achievement as measured on the Smarter Balanced Assessment Consortium Summative Assessment in Mathematics?
3. How do teachers incorporate the product into their instruction? What different strategies are observed? What influence, if any, does district policy have on product use?
4. How do students engage with the product during school? What structures and features are in place to support student engagement? How does the product work to engage students? Is it being used in a way that supports personalized learning?
5. What do students think about the product? What do they perceive as the product's advantages and disadvantages?

To address questions 1 and 2, data agreements were arranged with the districts to obtain student-level data for all 7th grade students, including SBAC scale scores and edtech product usage. To address questions 3 and 4, we conducted 38 observations across 6 classrooms (2 periods for each of the 3 participating teachers) This yielded 79 written field notes[2] which included transcribed conversations between students and with observers. In addition, we conducted 9 teacher interviews, which were transcribed and analyzed. To directly address question 5, 16 focus groups of 8 to 10 students from the participating classes were conducted at the end of the study.

i-Ready

One of the products used in the six classrooms and across the two districts was i-Ready. Developed by Curriculum Associates, i-Ready is an individualized platform serving grades K–8 that provides diagnostic testing and scenario-based lessons in mathematics and English. The diagnostic test has been shown to correlate highly with standardized test scores (Educational Research Institute of America (ERIA), 2016) such the SBAC, and thus is a useful benchmark for students, teachers, and districts. In the participating districts, students took the diagnostic test three times in the year: at the start of school, at the midpoint, and at the end of the year. Requirements for using the

2 A full field note can be found in Appendix D.

Table 1: District Demographics

	District A Number of Students	District A Percent of Total Enrollment	District B Number of Students	District B Percent of Total Enrollment
Total Enrollment	11,624	100	10,362	100
Ethnicity/Race				
African American	156	1.3	373	3.6
Asian	1,338	11.5	2,062	19.9
Hispanic or Latino	9,154	78.8	4,982	48.1
White, not Hispanic	194	1.7	1,851	17.9
Other	782	6.7	1,094	10.6
English Learner Status				
English learner	5,098	43.9	3,029	29.2
Non–English learner	6,526	56.1	7,333	70.8
Free and Reduced-Price Lunch Status				
Yes	10,419	89.6	4,701	45.4
No	1,205	10.4	5,661	54.6

Source: California Department of Education.

lesson portion of i-Ready varied in the districts, schools, and classrooms we observed.

School District Context[3]

Districts A and B are public school districts located in Silicon Valley. While the districts' buildings and infrastructure are far from state-of-the-art, the students are very aware of the tech culture of the area. One indicator of this is that during an informal poll, students said they would like to have a job someday at one of the large tech corporations located in the area. Only two of the three classrooms had smartboards and had one computer available per student. During most visits we observed struggles with hardware and software glitches, and problems with connection to the internet — all of which consumed valuable instruction time. From the demographic breakdown below you can see both districts have a majority Latino population. District A has a larger percentage of students who qualify for free and reduced lunch (90 percent versus 45 percent) and a larger percentage of students classified as English language learners (44 percent versus 29 percent).

3 All district, school, and teacher names have been obscured to preserve anonymity.

IMPACT OF i-READY ON STUDENT ACHIEVEMENT

An impact evaluation was conducted to understand if student use of i-Ready impacted student achievement as measured by the state standardized test, the SBAC. If there was an impact, we then wanted to know how dosage level (amount of time spent on i-Ready) factored in and if there were any differences in impact for student subgroups. During classroom observations we noticed that students who were less confident or less proficient in math did not engage with i-Ready as efficiently as students who were more proficient in math. This observation was confirmed by our teachers, as exemplified in the quote below. Thus, we were particularly interested in how proficiency level impacted student outcomes when i-Ready was used.

Observer: Last question, and then you have students. So, when you think about your groups, you have your All-Stars [highest proficiency], Veterans [middle proficiency], and Rookies [lowest proficiency]. Do you see a variation in their use of technology?

Teacher C: Oh yeah, I know All-Stars, they will just like get the work done. They'll fly through it actually, for them it's a little repetitive, but they get work done for the most part. For the Veterans, they're a little more motivated, a little bit more willing to use the strategies that they have in place. With the Rookies, which is my lowest level, I think that's the one group that is a little more resistant because sometimes they don't feel confident enough on the task. So, it's very easy for them to just sit there and watch a video and not do anything else. It's easy for them to sit there and look at the screen and not explore any strategies where they can help themselves in a sense.

— Interview with Teacher C, District A, School 2

Below we first present the overall impact of i-Ready usage as a function of the amount of time students spend in i-Ready lessons per week. We further refine this analysis to understand how the use of i-Ready differs with student growth along the SBAC continuum: from not meeting standards (level 1), to nearly meeting standards (level 2), meeting standards (level 3), to exceeding standards (level 4). Finally, we explore the variation in student growth as a function of baseline proficiency level on the SBAC.

Table 2: Study Sample

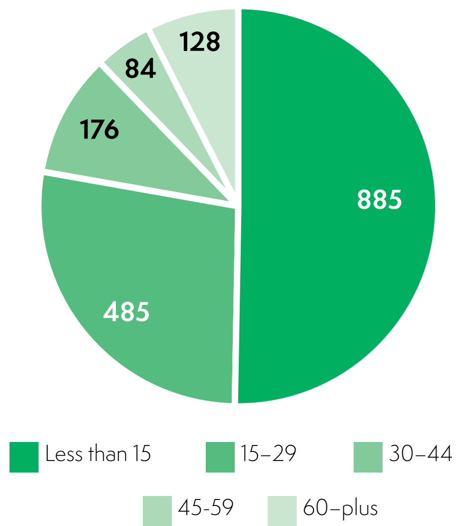
Student Characteristics	Study Sample Number (n = 1,759)	Study Sample Percentage
Gender		
Female	849	51.7
Male	910	48.3
Ethnicity		
Hispanic or Latino	1,088	61.85
Asian	380	21.60
White, Not Hispanic	187	10.63
Other	104	5.91
English Learner Status		
English Learner	454	25.81
Non–English Learner	1,305	74.19
Special Education Status		
In Special Education	199	11.31
Not in Special Education	1,560	88.69
Time on i-Ready Lessons		
45 minutes or more	212	12.05
Less than 45 minutes	1,547	87.95
30 minutes or more	388	22.06
Less than 30 minutes	1,371	77.94
15 minutes or more	873	49.63
Less than 15 minutes	886	50.37

Source: Student records data collected from the two school districts in the study sample

Impact of i-Ready and Inquiry into Dosage

To understand the impact of i-Ready on student achievement, we obtained student-level data from the i-Ready technology tool, and from the districts standardized yearly assessments and demographic information all 7th grade students. The i-Ready data included time on lessons and interim assessments, and scores on the interim assessments. The standardized assessment data included the SBAC math scale scores and achievement levels. The demographic information included gender, ethnicity, English learner status, and special education status.

Figure 1: Weekly Minutes on i-Ready by Number of Students



Source: Student records data collected from the two school districts in the study sample

The study sample included all students with no missing data for any of the variables included in the analysis. The study sample included a total of 1,759 students. Latino students composed the largest ethnic group within the study sample, at 62 percent. English learner students composed at 25 percent of the study sample, and students in special education composed 11 percent of the study sample.

Just over 50 percent or 886 students used i-Ready for less than 15 minutes a week, while only 12 percent or 212 students used i-Ready for 45 minutes or more, as recommended by the technology developers.

Students in the highest SBAC achievement level, level 4 (exceeding standards), spent more time in the lesson activities compared to students in the lowest achievement level, level 1 (not meeting standards). Students in achievement level 4 spent approximately 6 more minutes per week in i-Ready than students in achievement level 1.

Using a quasi-experimental design, specifically a matching analysis, we first tested i-Ready's claim that using the program for 45 minutes a week would have a positive impact on students' SBAC scores. According to i-Ready developers, i-Ready should be used at least 45 minutes per week to have a positive impact on standardized assessment scores (Curriculum Associates, n.d.). Since there was a difference in time usage between the students in different achievement levels, the evaluation included three impact analyses, each one with different time frames: 15 or more minutes, 30 or more minutes, and 45 or more minutes per week. The students in each of the analyses in those time frames are called the "treated" group throughout the report. The students who used i-Ready for less than those times are called the "control" group throughout the report.

The matching procedure included matching "treated" students to "control" students with similar characteristics. The following variables were used for the matching analysis: grade 6 SBAC math assessment, first i-Ready interim assessment, English learner status, special education status, gender, and ethnicity. The ethnicity categories included Latino, Asian, White, and Other. The Other ethnic category included African American, American Indian, Native Hawaiian or Pacific Islander, and Two or More Races[4].

Grade 7 SBAC math summative assessment was the outcome measure for the three impact evaluations. SBAC is administered to students during the spring semester and assesses

4 A baseline equivalence test was conducted on the final analytic sample for the three models using the grade 6 SBAC math summative assessment. The standardized mean difference of 0 was found for the 45- and 15-minute model. A mean difference of 1 was found for the 30-minute model. The mean difference of one or less signifies that both the treated and control groups are similar.

Table 3: Average of Total Lesson Minutes Per Achievement Level

Grade 6 Achievement Levels	Adjusted Mean Minutes Per Year (Standard Error)	Adjusted Mean Minutes Per Week	Total Students
Level 1	561* (30.2)	19	657
Level 2	632 (31.8)	21	483
Level 3	680 (40.0)	23	326
Level 4	758* (44.4)	25	293

*Statistically significant difference at the 5 percent level

Source: Student records data collected from the two school districts in the study sample

Note: The total number of weeks in school year is equal to 30 weeks. This excludes the additional weeks for winter and spring break, and interim and summative assessment time.

students against grade-level standards.[5] Once we determined that use of i-Ready correlated with positive SBAC achievement, we set out to investigate the differences in engagement between low- and high-proficiency students that we observed in the classroom.

Dosage Findings

As discussed earlier, students with higher achievement levels tended to use i-Ready more often than students with lower achievement levels. When examining the impact among students using i-Ready for 45 minutes or more, it was found that these students tended to score 24 points higher than similar students who used i-Ready for less than 45 minutes.

As i-Ready usage decreased, the differences between the treated and control groups decreased; there was a 19-point difference for the 30-minute impact analysis and a 7-point difference for the 15-minute impact analysis.

When examining the growth of the treated group who used i-Ready for 45 minutes or more and the control group, on average both the treated and control groups stayed within the same achievement level (level 3). However, on average the treated students' growth increased 73 percent toward achievement level 4 compared to the control group's growth that increased 38 percent[6].

When examining the impact of the 30 minutes or more time frame, both treated and control students moved from achievement level 2 (standards nearly met) to achievement level 3 (standards met). To investigate how much growth the 30 minutes or more treated group and the control group gained within level 3 achievement, a separate growth analysis was conducted. Students who used i-Ready for 30 or more minutes progressed 35 percent in achievement level 3, compared to similar students who used i-Ready for less than 30 minutes, who only progressed 6 percent in achievement level 3, with the understanding that achieving 100

5 The SBAC is a computer-adaptive test. https://www.cde.ca.gov/ta/tg/ca/documents/sbsummativefactsheet.pdf

6 The calculation for percent growth toward the next achievement level is provided in Appendix A.

Table 4: Impact by Weekly Time Spent on i-Ready

	Treated Group (standard error)		Control Group (standard error)				
	Mean	Mean Achievement Level	Mean	Mean Achievement Level	Adjusted Mean Difference	Number of Students in each group	Effect Size
45 minutes or more per week							
Grade 7 SBAC[a] Math Scale Score	2616 (104.5)	3	2592 (102.6)	3	24**	212	0.220
30 minutes or more per week							
Grade 7 SBAC Math Scale Score	2590 (113.2)	3	2571 (114.8)	3	19**	388	0.169
15 minutes or more per week							
Grade 7 SBAC Math Scale Score	2549 (113.6)	2	2542 (118.8)	2	7*	873	0.060

Note: 7th grade SBAC achievement level scale score ranges are Standards Not Met: 2250–2483; Standards Nearly Met: 2484–2566; Standards Met: 2567–2634; Standards Exceeded: 2635–2778

**denotes statistical significance at the 1 percent level

* denotes statistical significance at the 5 percent level

Source: Student records data collected from the two school districts in the study sample

Table 5: Impact of 45 Minutes per Week on i-Ready

Students	Grade 6 Scale Score	Grade 6 Mean Achievement Level	Grade 7 Scale Score	Grade 7 Mean Achievement Level	Percent Growth Toward the Next Achievement Level
45 or more minutes	2567	3	2616	3	73
Less than 45 minutes	2567	3	2592	3	38

Source: Student records data collected from the two school districts in the study sample

Note: This growth helps us understand how far the students have increased toward the next achievement level.

Table 6: Impact of 30 Minutes per Week on i-Ready

Students	Grade 6 Scale Score	Grade 6 Achievement Level	Grade 7 Scale Score	Grade 7 Achievement Level	Percent Growth toward the Next Achievement Level
30 or more minutes	2542	2	2590	3	35
Less than 30 minutes	2541	2	2571	3	6

Source: Student records data collected from the two school districts in the study sample

Note: This growth helps us understand how far the students have increased toward the next achievement level.

Table 7: Student Growth and Time on i-Ready

	45 minutes	45 minutes	45 minutes	30 minutes	30 minutes	30 minutes
	Total students	Move to the next achievement level	Percent moving to the next achievement level	Total students	Move to the next achievement level	Percent moving to the next achievement level
Level 1	33	17	51.5	99	34	34.3
Level 2	48	23	47.9	90	39	43.3
Level 3	51	32	62.8	89	52	58.4
Level 4	80	0	0	110	0	0
Total	212	72	34.0	388	125	32.2

Source: Student records data collected from the two school districts in the study sample

percent growth would land the student into the next achievement level.

When comparing the 45- and 30-minute impact analyses, we note that a percentage of students in all levels moved up an achievement level. However, a higher percentage of students moved levels when using i-Ready 45 minutes or more compared to students using it 30 minutes or more. Also, in both analyses the impact is greater for students who were higher achieving in 6th grade; A higher percentage of level 3 students moved up than level 2, and a higher percentage of level 2 students moved up than level 1. Similar patterns persist for the 15-minute per week analysis, in that this student group saw the least impact from i-Ready usage. This information is provided in Appendix A.

Discussion and Recommendations

The three impact evaluations find that i-Ready significantly improves math achievement as measured by the grade 7 SBAC summative assessment. The findings also show that the more minutes students spend on the lessons in i-Ready, the higher the differences in scale scores compared to analytically similar students using i-Ready for fewer minutes. Specifically, in the case of students who used i-Ready for 45 minutes or more each week, students showed 35 percent more growth in their achievement level than their analytically similar peers who spent less than 45 minutes a week on i-Ready. The growth on the SBAC score places these students more squarely in the achievement bracket and may support them toward continually meeting standards each year.

This pattern of findings suggests that i-Ready is an important edtech product to be used in the classroom, but there must be an increase in usage for students in lower achievement levels. This is supported by our finding that students in achievement level 1 (standards not met) spend fewer minutes on i-Ready than students in achievement level 4 (standards exceeded). A further analysis needs to be conducted to understand the reasons why students in achievement level 1 spend fewer minutes on i-Ready and how they can be supported. Additionally, an impact analysis that includes all edtech product usage in the classroom should be considered to isolate the impact of one product from another.

Standards in 6th, 7th, and 8th grades provide a base for students to succeed in high school math (Adelman, 1999). This study sheds some light on how technology can influence a student's individualized learning and potentially set a student on the right math path.

Limitations of the Quantitative Analysis

This quantitative study has two types of limitations: one that deals with the impact of other edtech products and the other with the generalizability of the results.

While visiting the classrooms, we noticed that there were many additional edtech products that were used. Some edtech products were selected by the teacher, while others were encouraged by the school district. Additionally, there were different types of implementation of the i-Ready lessons. Some teachers used i-Ready for homework, while others provided class time (additional information on this in the discussion of the qualitative findings). These different types of implementation and additional edtech products might impact the analysis and would need to be investigated to understand the sole impact of i-Ready.

Additionally, the study sample is limited to students from two districts in Silicon Valley, and the findings may be generalizable only to districts that are similar to the study sample.

i-READY IN ACTION: STUDENTS' VIEWS AND CLASSROOM OBSERVATIONS

It is not enough to know that a product can work to support learning. To serve all students equitably we need to understand implementation — how and in what ways students and teachers engage with the product. To understand implementation, we collected observational, interview, and focal group data on the edtech products.

There was no intervention nor specified product of study around which our work was organized. Rather we entered classrooms with the aim of discovering what products were in use and allowed our observations to organize the study. We chose i-Ready as a focal product because of the importance of the diagnostic capacity to the participating districts, its ubiquity in the participating classrooms and because of the ease of access to product data. Our focal classrooms, however, had a variety of differing implementation strategies for i-Ready. The demographic and math proficiency profile of each class varied as well. As discussed above in our observations, we noted a difference in attitude towards and engagement with i-Ready related to observed math proficiency.

Data Collection and Analysis

In Table 8 we detail the various data collected over the course of the study. Observations were conducted in clusters — we organized three to four observation weeks per school and conducted two to three observations during those weeks. In general, we took the stance of participant-observer in the classroom. This meant that we did not simply stand back and take notes. Rather, we sat with students at computers, asked them about the tasks they were doing, and often acted as a tutor when they were stuck with the math. In that capacity all observers aimed for the best practice of supporting students in productive struggle — either with the math or with the product use — rather than explaining the math, providing instruction on the problem, or explaining how to use the product. The exception to this was during the two class periods when we observed the diagnostic test, and when students were taking an end of unit quiz. At those times we simply observed.

Table 8: Qualitative Data Collected

i-Ready Specific Data	District A, Teacher A	District A, Teacher C	District B, Teacher B
Observation field notes	34	17	28
Teacher interviews	3	2	4
Student focus groups	6	3	8

After many of the observations, observers and teachers met to discuss the day and their understandings of what was observed. In addition, each teacher was formally interviewed at least two times.

At the end of the study, we conducted focus groups with all the students who chose to participate from the three classes. Focus groups contained eight to ten students and were facilitated[7] by the WestEd or iHub team members who conducted observations and were thus familiar with the students and their work on the product.

Analysis

Analysis of field notes, interviews, and focus group transcript data was completed utilizing an integrated approach — drawing from both deductive and inductive coding methods. Following Miles and Huberman (1994), the team defined a series of code categories related to personalized learning, user interface, and math learning and assessment. With these categories as a structure, the team applied the principles of inductive reasoning and the constant comparative method (J. M. Corbin & Strauss, 1990) to identify emergent themes and refine deductive codes.

Field note data was coded by a single researcher. Focus group transcripts were coded by a team of three and followed a standard intercoder reliability process (Miles & Huberman, 1994).

Observation Classrooms

District staff selected participating classrooms based on the teachers' engagement with technology. In addition to various edtech products, all participating classes used College Preparatory Mathematics (CPM) as a primary textbook. A brief description of the classroom environment, the technology set up, and how i-Ready was used follows.

Between the classrooms there is a good degree of variation in our focal schools on time spent on i-Ready and average proficiency in math as measured by the SBAC. Most of our i-Ready observations occurred in a classroom where students spent an average of 30 minutes per week on i-Ready, and whose 7th grade SBAC scale score average was in level 1 (mean = 1.76, SD .76). These students were the least mathematically proficient students in our observations. The most vocal and nuanced critiques of i-Ready came from the students in District B, School 1, Teacher B's class. This is perhaps because they were such heavy users of i-Ready (averaging 78 minutes per week), but also, their project-oriented curriculum prepared them to speak critically in group settings. Teacher C's students were low users of i-Ready, but high users (in our observations) of other edtech math products. Still, the overarching patterns of critique from students, observed usage patterns, and teacher views remained

7 Ethnographic interview protocol can be found in technical Appendix C.

similar across the schools despite the implementation differences laid out below.

District A

While the district requires teachers to administer the three i-Ready diagnostic tests, it is up to the individual school sites to oversee the amount of lessons each student needs to complete. Teacher A used i-Ready in class regularly, Teacher C did not. In our interview with Teacher C, he explained he used to assign students i-Ready lessons as homework but discovered that many students struggled to access the product and worried it was creating an inequitable environment. Students in this class did not have as much to say about i-Ready lessons in the focus groups, though they were familiar with the diagnostic tests. We did not observe the product in action in this class.

Teacher A used a blended classroom model where there were three stations: a direct instruction station, a station where students could collaborate and learn individually, and a station where students could choose between i-Ready and two other math products to supplement the other skills being taught in class. The students were organized heterogeneously, so each group had a range of math proficiencies represented.

On the days we observed, Teacher C also used a blended classroom model with a direct instruction station, a station where students typically worked on problem sets in a Google document, and a station where students used a math edtech product. Numerous products were used in Teacher C's classroom.

District B, Teacher B's Classroom

In Teacher B's classroom, edtech product work was expected to be done individually. Teacher B used notebooks in conjunction with edtech but did not require students to copy all their problems in the notebook. Teacher B used numerous edtech products in her class and was constantly on the lookout for new products to support her students' learning.

The district mandates the three diagnostic tests, as well as completion of the i-Ready lesson modules. Teacher B assigns the lessons as homework and students are held accountable each month to have completed the assigned lessons. One period every other week is designated for working on the i-Ready lessons. Described in detail below, Teacher B also allowed us to observe during the first day of the interim i-Ready diagnostic testing.

Teacher B's students performed better on the SBAC and spent a lot more time on i-Ready than the rest of the seventh graders in the study sample from both districts. The differences are statistically significant.

Qualitative Findings — Major Themes

For the remainder of the paper, we work to describe in rich detail the interactions we observed and to bring forward the voices of the students and teachers as they worked with i-Ready. In triangulating the three perspectives of observer, teacher and student, we aim to create a picture of i-Ready implementation. Each section is organized around an element or theme that rose to the surface during our analysis of the field notes and transcripts. Some came forward due to the frequency with which they were noted, and others came forward because they helped us understand potential impediments to engagement with the product.

i-Ready Features

Scenario-Based

i-Ready is a scenario-based product — each lesson begins with a math-integrated story narrative. The lessons we observed contained a handful of human and animal cartoon-style characters who narrated and participated in the stories. For some students and in some lessons the stories worked well, as described below:

> **Student 1:** Okay, so the reason why I've been adding and subtracting integers is because I remember this lesson. It included hot wings and celery. The hot wings were negative and then the celery was positive, and I found that effective because when I think of adding and subtracting integers, it reminds me of that. The lesson kind of went like watching a football game and then they were eating the typical football game food like hot wings and celery and they were just laying it out. There was an equation; they were laying out the negative hot wings and the positive celery and like putting it into zero pairs and seeing what the result is. Yeah, I found that helpful on i-Ready, but sometimes it would over-talk. Yeah. I still remember that. It was kind of a long time ago, but I still remember that.
>
> **Facilitator:** But, it's something that stuck in your head. Does anyone else remember that lesson?
>
> **Student 2:** Yeah, I actually had that one yesterday.
>
> **Facilitator:** Really.
>
> **Student 2:** Yeah, they talk a lot, most of the beginning and then they give you a few problems, but it gets off topic sometimes, like they just start talking about the game.
>
> — *Focus group transcript: District B, Teacher B's classes*

The zero pairs lesson embedded in a football game story described above was mentioned in several focus groups, and in many ways encapsulates the paradox of i-Ready's structure for the 7th graders. Often, the lessons have catchy elements that help concepts stick; however, the lessons feel long to the students. Students frequently mentioned that the characters talked too much and that the story was over embellished.

Perhaps in part as a result of the long stories and in part out of a desire for choice in their learning, students often discussed wishing for more control within i-Ready. They mentioned wanting some sort of control over how they go through the lessons. A common sentiment around student choice and lesson progress is expressed in the following exchange:

> **Student 1:** ...You take a test and they give you lessons based on what they think you know and you don't know. But let's say you learned that concept in class, and then you go to i-Ready, and you're going to go to i-Ready and it gives you the same thing that you learned in class, and then you just have to work for an hour on something that you already know how to do, it's just really repetitive.
>
> **Student 2:** Yeah, or if they had something before like, "Let's see how good your knowledge is on this beforehand ..."
>
> — *Focus group transcript: District B, Teacher B's classes*

This desire to have their knowledge checked before embarking on a lesson, or to have the option to test out of a lesson was a common proposed remedy to the student-perceived problems of redundancy and time consumption of i-Ready lessons. As educators, we know that practice in math is necessary — and if this is the logic behind having students complete lessons regardless of their proficiency in the topic, it is important that teachers and products make this clear to students. Certainly, in the case of these students it was not a lack of interest in math driving the critiques. Rather, they expressed a desire to be met where they are in terms of age appropriateness in design and in terms of their current mathematics knowledge.

i-Ready has moments in which students felt enough control that they were able to overlook the storylines which they described as childish and overstated. This can be seen in the discussion around a lesson set in an Alice in Wonderland story:

> **Facilitator:** Yeah. So what are the facets of that style that make it good? Go ahead.
>
> **Student 1:** You could go back to it if you still need more help on it or more time with it.
>
> **Student 2:** It helps to have more [time] obviously. You don't feel like you're being rushed to understand so you can move on.
>
> **Student 3:** They let you just play around with it, see if you could figure it out on your own.
>
> **Student 1:** They let you choose when you want to leave so if you understand the topic, you can leave it early and if you don't, you can use as much time as you need on it.
>
> **Student 4:** [...] This time, it's not just like set questions with set answers. It is still a set question, but the way you find that answer is changing, and you can find a better way to represent it. Also, another thing I like with that lesson is how if you do get that answer wrong, it brings you back to the app but with restricted access to make you focus more on the result it wants you to see.
>
> — *Focus group transcript: District B, Teacher A's classes*

Students in this conversation are discussing a desire to have an interactive and engaged relationship with the material presented to them. This type of inquiry should be encouraged in students through all our educational supports.

At times we observed students returning to their notes on specific math in order to complete a problem. Below a student is on a lesson quiz that he remembers completing but cannot get past. He continues with it because he says he does not want to bother Teacher B, but expresses frustration at a task, the quiz, he feels is an incorrect assignment. Below is the interaction with the observer:

> I asked Jay[8] what property or operation he would use. He said division and then articulated what he should do with the problem, but then got held up on how to do division with fractions. After going down a rabbit hole with some incorrect conversions, he got pretty close and I went to check on the other students.
>
> Jay had gone to his backpack and gotten out his notes on how to divide fractions, but he still was not sure about how to convert the mixed number to a fraction, or the total process. He started out on a clean paper writing down the problem and we talked through the conversion. Then he remembered flipping one of the fractions and had an answer — but it did not match anything on the multiple choice. I then reminded him how he changed the first mixed number to a fraction, and he realized he could change his fraction back to a mixed number. That matched one of the answers. He selected it and was relieved. All throughout he kept saying he was bad at fractions. I said, fractions are just hard! You were so persistent — I thought you did great working so hard on it!
>
> — *Field note 171009: District A, Teacher A's class*

We will discuss in more detail the complicated interactions between edtech products and the technologies of paper and pencil; however, a question arises as to how contained a product should be, and what role students' notes and other external sources should play.

A final i-Ready feature that bears mentioning is what happens when a student takes

8 All student names have been changed to protect their identity.

the end-of-lesson quiz and receives a score of less than 70 percent correct. Every focus group touched on this issue, which is summed up below:

> **Student:** Well, I don't like it when i-Ready … like you failed a lesson and it makes you do it over and over again until you get it, and sometimes I'll be doing that for like weeks up to a month until I get it.
>
> **Facilitator:** Until you get it right and is it the same exact same lessons or do they change the problems?
>
> **Student:** It's the exact one.
>
> **Facilitator:** It's the exact same one, okay. Has anyone else faced that problem?
>
> **Students:** (in unison) Yeah.
>
> — *Focus group transcript: District A, Teacher A's class*

Students explained that they often did not know what problems they got wrong or what in the lesson they did not understand or why they failed. In our focus groups, students discussed repeated failure as one tactic for progressing out of a lesson. In this vein, students also expressed frustration with the obtuse nature of the reporting. For students, knowing they went down in points in fractions is not enough information. Universally, they wanted to know exactly what answers they got wrong — or as one group suggested, at least a selection of wrong answers. One remedy for this is, again, in allowing students more control over the navigation of mathematical content. If students can address the specific elements of the mathematical content in the lesson that they are not proficient in, they can take ownership of their learning.

In summary, the scenario-based format of i-Ready has benefits for students and is at its best when students have the ability to interact with how they move through the scenarios. Students would like the power to speed up or slow down instructional sections and to see some trimming of the storylines. Greater transparency about the role of the lesson may help student engagement as well. At the 7th grade level, explaining to students that practice is important, even when they understand the skill, may make repeating of concepts and lessons more palatable; yet being able to test out of lessons seems reasonable. Products should work to find this balance.

Challenges with i-Ready

Educational products are different than productivity products in their striving for containment. Yet they rarely succeed — and perhaps this is not an appropriate design goal. Inside a product, should students be able to search for how to divide fractions? Could the product, when it senses a lag, suggest that students look for additional information elsewhere? Should the product support students to find other resources, perhaps linked with their school textbooks or other online resources? What would it look like if the student in the description prior could click through to a resource on dividing fractions? What if that resource was the student's own notes? Common Core standards require students to develop academic discourse skills — perhaps one support for this would be notetaking inside products, and then having those notes available during lessons to be revisited and even refined.

Collaboration and Persistence Doing Algebra

In Teacher A's classroom, collaboration was the norm. We observed students sharing resources like calculators, paper, and pencils, and working together on problems for homework before school and in class. When students were stumped at the computer, they first turned to a friend before asking an adult for help.

i-Ready is not designed for collaboration nor for adults to support students in their use of the product. i-Ready relies heavily on verbal instructions provided by characters. In the classroom, this means the product is not very effective unless the students have headphones. In Teacher B's class, students could use school currency to rent headphones for the day if they forgot theirs. In Teacher A's class, students would often use the product without the sound when they forgot their headphones. From the perspective of an observer, the reliance on verbal cues often made it challenging to understand what the product was asking of students, and how to support students when they got stuck.

On the day described in the field note below, three students struggle together to understand an algebra problem. They were not unfamiliar with this type of problem, having had a worksheet with similar problems the day before. Yet the descriptions below show that they struggled to complete the task on i-Ready:

> The three girls and Ignacio were all in the same algebra section I had seen the day before. At first, they had the "estimate screen" where there was a dial on a vault that they moved to select different numbers to solve the equation. At one point, Ignacio is trying to get past the estimate screen. He gets past and I say, "I have no idea what happened there." He laughed and said, "Me neither, I was just clicking buttons."
>
> *— Field note 171010: District A, Teacher A's class*

During two specific lessons, precise movements of an object on the screen was difficult using the trackpad, and this frustrated students — even when they knew what answer they wanted. In one example, an estimation screen was particularly challenging in that it required a correct answer to a problem presented before moving on — not an estimation. Students in many focus groups expressed frustration around this specific feature. After the students passed the estimation screen, the following occurred:

> [A penguin] introduces the problem saying, "Using the principles of equivalency and inverse operations, isolate the variable," and then puts up the screen where the student needs to choose what operation to use. I watch as Danielle clicks through the operations and ask her:
>
> **Observer:** Do you know what it is asking you?
>
> She says, "Umm, not really."
>
> **Observer:** Well, what does it mean when it says isolate the variable?
>
> **Danielle:** Subtract?
>
> **Observer:** No but, um, what does isolate mean, do you know what isolate means, the word?
>
> **Danielle:** No.
>
> *— Field note 171010: District A, Teacher A's class*

We applaud i-Ready's use of the type of math discourse students will see on assessments like the SBAC. However, vocabulary issues like the one above were common in our observations of all products. Almost every field note contains a description of a student struggling with the words in a problem. In this instance, as in many instances, words only appeared on the screen while the penguin was speaking. Students were not able to find a place in i-Ready to look up unknown vocabulary or find mathematical facts. Although the observer reported helping Danielle develop a definition of "isolate" and understand the problem, it is clear from the next interactions around this lesson (described below) that neither she, nor the other students next to her, were working with the mathematical principles called for:

Field Note Text	Additional Description and Analysis
The girls are all on the same screen for a moment and are looking over at each other's computers. The problem is **140 = m + 80.**	The girls are being asked to use the principles of equivalency and inverse operations to isolate the variable.
They try out possible answers, talking to each other about them. However, they quickly discover that the same number does not seem to work as an answer for everyone. Since I am watching all the screens, I notice that what has happened is that they started on the same problem, but as they enter numbers to try, i-Ready calculates using that number, and then has them continue with the problem, in the way that the number they entered altered the problem.	Often when students saw this type of problem (which was frequent during this set of observations), students would put a number in the answer box, and i-Ready would then subtract that number from both sides, resulting in a new problem. Then, this "new" problem is at the top of the screen. Their prior work is wiped away. This caused confusion for students, even when they were not collaborating. Often, they treated these as separate problems. Or they might try to go back to understand what happened.
As a result, Danielle, who is moving the quickest, asserts the answer is 20. What she did is as follows: Types in subtract 40 from both sides. The work is shown: 140 = m + 80 -40 = -40 100 = m + 40 Then it clears all this work and puts at the top of the screen: 100 = m + 40 Danielle enters 20 two times and it shows m = 60. However, since she entered 20 as the last number in the box, she asserts to her classmates that the answer is 20, 20 is the number to put in the box.	What many students tended to do when they saw these problems was to try to find the variable value and enter that into the box. In this instance, Danielle enters 20 three times to get successive new problems, and eventually the product shows the result of m = 60. However, she understands the answer to be 20.
Audrey is skeptical and takes the calculator and begins doing the math. She thinks the number to put in the box is 60. Ignacio enters the conversation, and also states the answer is 20. When Audrey shows on her screen that the answer is 60.	Audrey , experiencing a similar confusion to Danielle's, enters numbers but eventually gets to a screen that says 60 = m. Thus, she believes the answer is 60.
Ignacio expresses confusion, saying "huh" and looking to me and to the screen. Ariana, who already finished the problem and has a new one up, enters the conversation saying she entered 60. Danielle finally puts in 60, but she has already done 20 some number of times, so it comes out as a negative number, and clearly incorrect.	Again, the successive math without showing the entire problem creates confusion and thwarts the students from supporting each other's learning.
Ignacio again expresses confusion. He backs out of his screen and goes to start again.	Ignacio started back at the estimation screen no fewer than four times in the course of the period, trying to go back to the last screen, or get to the same spot as Danielle and Audrey.

— Field note 171010: District A, School 1

In Teacher A's class, we observed two types of students — those who regularly sought to collaborate and problem-solve with their peers, and those who worked through the problems relatively independently. In general, students who were collaborating were struggling with the math and seeking help. This example displays several challenge points for students with i-Ready. The lack of "crumbs" means that students are unsure of what they did last and how it connects to what is on the screen currently. Here, it resulted in students being unclear as to where they were in the problem and why different numbers appeared to work as answers. In several field notes, observers described students pressing the wrong button either to finish a module or to try to go back a screen, resulting in them having to redo the entire lesson. Students bemoaned the time lost (anywhere from 45 minutes to an hour) that this meant. In the example above, Ignacio, trying to get on the same page as Danielle, ends up at the estimation screen no fewer than four times, each time more confused than the last.

The students were incredibly persistent in their work together. As with most of the students we observed in these classes, they were engaged in their learning. They were not off-task much, although having two observers to support engagement certainly had an impact. However, particularly in the case of these students, more support was needed for understanding.

While i-Ready is designed to be used individually, struggling students need additional supports to successfully move through edtech products. Changes to the structure that would allow students more control would also facilitate their ability to collaborate and compare work. Additional student control over progression in the product could also support any sort of tutor or adult assistance. At the same time, these features could also satisfy students' expressed desire to be able to move through the product with more freedom and at a self-chosen pace.

Writing, Computation, and Edtech Products

Thinking mathematically, performing computations, understanding geometric shapes, and setting up algebraic problems "in your head" without some sort of representation, either through writing or the use of a calculator or both, is quite hard. Yet we often observed this when students were working with the edtech products. We observed a complicated and somewhat fraught interaction between the edtech products and the technologies of paper and pencil, the trackpads used to interact with the computer, and calculators both inside and outside of the products. Even the physical space could be an impediment, because desk space was often insufficient for a keyboard and a notebook to comfortably sit. Below we describe the different ways we observed students engaging with these technologies while using i-Ready.

Hardware and Software

All the classrooms we observed exclusively used trackpads and keyboards to engage with the edtech products. There were no touch screens or styluses in use, and only one student out of the approximately 90 we observed used a mouse. This meant that the workspaces designed for writing out computations or formulas provided by products were nearly impossible to use. i-Ready does quite well in this environment, because in our observations, students rarely struggled to manipulate items on the screen to solve problems. Engagement with non-product supports still needed to be supported, and this was handled differently by different students and teachers.

In Teacher C's class students were expected to keep a detailed notebook of all the problems they worked on in any edtech product. Teacher B also encouraged students to write down their work, and at times students' notebook work was part of their assignments. Teacher A used worksheets in one of his stations, so students were accustomed to writing out their work; when working with edtech products, students varied in their use of paper to support their thinking in his class.

We observed some very creative ways that students attempted to "write" using the track-pad in the workspace the product provided on the screen when they did not want to use, or did not have access to, paper and pencil. These moments were excruciatingly time consuming; it could take up to a minute to "draw" a number in this fashion. In i-Ready this would happen while using the in-product note pad. Only one field note discusses a student using it, and after watching it in action, the observer suggested the student use paper and a pencil.

Writing Resistance and Error and Efficiency

In Teacher A's class there were some students who used scratch paper, some used notebooks, and most had little calculators. There were a few ways we observed students engaging with paper at the computer stations when working with i-Ready. Some students quickly got out a note-book and pencil and did computation or wrote out problems for almost the entire time. Others exclusively reached for paper when they were stuck, and still others only turned to paper to help them work out a problem when prompted by an adult. We describe all these below.

The student discussed in the field note below, Virginia, was struggling with basic alge-bra and used scratch paper constantly. She often copied what was written on the screen in its near entirety before beginning a problem. None of the field notes on Virginia show a transcription error; however, she did spend a long time on each problem. As shown below, she seemed not to understand exactly the algebraic work — rather, these became computation problems. On this day, there was the added difficulty of no sound — Virginia had forgotten her headphones.

> After a few minutes I went to the other side of the students, and sat down next to Virginia, the one student who did not have headphones. She had a sparkly green calculator, with a carabiner attachment and well-worn buttons. She was bent over a piece of lined paper, working on an addi-tion/subtraction basic algebra problem. The first problem she typed in numbers to a box on the bottom, and it went away quickly, but it did not appear that she had the correct answer, rather that she had used up her chances. The next problem was structured the same way. The screen had 140 = 125 + m on the top of the screen and then at the bottom asked: What would you subtract from both sides? with a box to fill in the number. She had worked a number of possible answers on her paper and went back and forth between her calculator, writing on her paper and her eraser. On her paper she had set it up as two columns, similarly to how the computer screen was set up. After a good degree of trial and error she came up with a number to try in the box. Then after some more trial and error on paper, she came up with the number, 15, to put in the box. Through this time, I watched quietly, trying to understand how she was engaging with the program and what it was doing. I noticed that the penguin in the corner often made movements that indicated it was talking, but neither I nor the student was able to hear what it was saying.
>
> *— Field note 171009: District A, Teacher A's class*

Virginia goes through a few problems like this, slowly working things out on paper, copying down directions and other static information, and then trying multiple possible answers. She never uses the canceling-out notations — nor does she get the problems correct in one attempt.

Some students just needed some encourage-ment to work out a problem. In a few field notes, observers watched students who seemed to be guessing at problems. Sometimes this guessing was confirmed by the student when asked. Many times, observers would interrupt the student and encourage them to show their work on paper, often providing the writing materials, as was the case below:

I asked a student if she could do the work in her head. I said, "Let's just do this together." It was 15 + 3(f — 13). At first, she got the equivalent expression incorrect. [...] I had the student complete the work on a separate sheet of paper where she distributed the 3 to f and to the 13. She didn't need any additional help other than a piece of paper to show her work.

— Field note 171011: District A, Teacher A's class

A few field notes describe students being resistant to writing. In some instances, students bemoan copying down problems, particularly when they have been assigned to show their work in notebooks. In other cases, like the one below, students want to do all the work in their head. At times, paper and pencil were not easily accessible or easy to use in the space, and this also created a barrier. There was not a pattern observed in students using writing to support their math related to the question type (multiple choice or fill in the blank).

Observer: Why don't you try writing down stuff? Cause then you can keep track, because this is just a little mistake that I think you wouldn't have made if ah ... So why don't you write anything?

[student completes another few problems making some simple errors]

Observer: What do you do on a test?

Student: I don't like writing in general. If I do a question I do it in my head and I finish it, I look back before I go to the next one, and then I look for any mistakes and I start saying it out loud to myself and I find if there is anything wrong with it.

Observer: I'm watching it here, and you know the math, you definitely know the math, but you make simple mistakes you might not if you wrote it on the paper.

— Field note 171115: District A, Teacher A's class

To focus students and make them more accountable for their work, two teachers required students to write out the problems they worked on the edtech products. All the products we observed provided the ability for students to do work on the screen, but none worked with the technologies available in these classes. So the question becomes: How can edtech products encourage students to look at and show their math, outside of the product? And then, what can be done to avoid transcription errors? In the observations of classes where students regularly wrote out problems, transcription was not an uncommon source of error.

Interim Diagnostic Test

While not in our observation plan, Teacher B invited us to observe while her classes began their i-Ready interim diagnostic test. To begin the class, Teacher B explained:

... unlike other times, she needed the students to show their work for each problem on the test. She told them if they had an equation to solve, they could write that down and show their work. If it was the type of question that they could not draw on the paper, then they just needed to indicate the answer they chose and write a sentence on why they chose it. She described keeping their work nice and neat, numbering them on the paper, even though they do not have numbers for the questions on i-Ready. A discussion erupted regarding how many questions there were on the tests. One student said 100, and then Teacher B rolled her eyes and said that she hoped not, because you (looking around the room, gesturing to all the students) would never finish. But she explained to the students that they all got a different amount of questions. However, she went on to explain, now they would know how many questions they got through numbering their work on the scratch paper. Roger, a boy in the front left set of desks, said, "We could take the mean!"

— Field note 171207: District B, Teacher B's class

All three focal teachers described a mismatch between what they knew of their students' math proficiency and what the i-Ready diagnostic tests showed. Teacher B hypothesized that the students went into "game" mode with the test and stopped being as thoughtful and careful as she knew they could be, instead treating it like a video game. Students themselves said they would become fatigued and reported just guessing at times. Asking students to show their work or reasoning for each problem was a strategy Teacher B decided to try to counteract these tendencies and help students stay focused. She was, however, concerned it would extend time to completion for testing — which was already scheduled for six class periods.

The emergence of a discussion on understanding the length of the test mathematically ("We could take the mean!") is characteristic of this classroom — student-initiated math discourse was common. Students at all sites were very aware of the adaptive nature of i-Ready lessons and testing, as is evident with Teacher B's almost offhand reference to the variation in the testing experience ("They all got a different amount of questions") going undiscussed.

Timing

i-Ready states that the diagnostic test should take 45 minutes. However, Teacher B and the other two teachers we spoke to allot five to seven class periods for testing. While there are setup and breakdown issues that take time, this is true of every instructional day, since the classes we observed use computers that are retrieved from a cart each period. Despite this being an adaptive test, it seems that students move at wildly varied paces in the test. For example, at the end of the period, approximately 40 minutes into the diagnostic testing, an observer recorded the following range in the number of problems students had completed on the diagnostic test:

2, 3, 3, 3, 3, 3, 4, 4, 5, 5, 5, 7, 7, 9, 10, 10, 11, 11, 11, 15, 17

When discussing this range with Teacher B, she noted that the girl who had completed 15 problems was probably doing fine as she was a high-level student. However, the girl at 17 problems was probably moving too fast. In total, students saw between 60 and 65 problems in this class. Considering this, considering and the range of completed problems after one class period, it is not surprising that the class ended up spending six days completing the diagnostic.

Teacher B bemoaned the completion time difference in the interim diagnostic from an instructional standpoint. Usually she has a few students who are not behind, but are just very slow at test taking. They end up missing days of instruction trying to finish the interim diagnostic so they can continue their i-Ready lessons.

Desire for Feedback

Teacher B had a selection of students who, before beginning the i-Ready diagnostic, were going to retake a quiz. This was an opportunity for them to better their score and move up a level in the class's math community structure. This quiz was delivered through another math edtech product and provided an opportunity to observe students' behaviors in the test environment of two different products. From the day's field notes:

> I watched Walt work on his quiz. His feet jiggled nonstop and each time he got an answer correct he pumped his fist up and down a few times while bopping in his seat. When he got an answer incorrect, he found a way to get a hint and completed the problem after that, although he knew that he would not get credit for it. In ten minutes, he was on to the i-Ready test. Nicolas,

the student sitting to the left of Walt, was still through the test, sitting noticeably upright. He wrote slowly and carefully on scratch paper, even though Teacher B was not collecting work for the [product] test. He took about five minutes more than Walt to finish the seven problems and when he finished the [product] quiz I noticed that he received 100 percent. I did not notice any visible nor audible acknowledgement of this achievement.

Walt's first i-Ready problems were testing vocabulary — the terms quotient and product. His next question asked:

Which is a composite number?

Answer Options: 81, 71, 41, 51

He stared at this for a long (>3min) time without moving in his seat. Eventually he selected an answer and then wrote on his paper that he had guessed. Next to him Nathaniel had the question:

The graph below represents the depth of the water as it runs out of the bath. What does the slope represent?

As he reads the problem he slowly begins to sink under the desk, until his body is a straight line, his back on the seat of the chair and his head hovering above the chair back. He pauses like that for a bit (less than a minute but more than a moment), then clicks an answer and sits back up. He bends over to write something on his paper I cannot see without feeling I am imposing.

— Field note 171207: District B, Teacher B

The affective shift as students moved from their quiz to the i-Ready diagnostic was palpable. The quiz was served on a product that students in this class consistently favored over other products. This may in part be due to the immediate feedback students received on problems, a feature they commented on frequently as positive. Students knew if they got an answer correct or not, and even though they would not get credit, they could work to discover the correct answer before moving on. One student had to be told to stop retaking the quiz — he had completed it four times in hopes of getting 100 percent.

The i-Ready diagnostic is not actually, in this mid-term moment, any higher stakes than the quiz — but it would not be unreasonable for the students to feel it is. They do know that it will impact which lessons they are asked to complete in the coming weeks. But also, not knowing the answer, potentially ever, is frustrating to the students, as expressed by these girls after the class was finished:

Student: Yeah like during the adaptive test, they give you questions and then you don't know if you got it right or wrong. But then your class still moves on and you still wonder if you got them right or wrong or if you even know much about that subject.

[interrupted by teacher announcements and class dismissal]

Student: To finish up what I was saying, with [other products] you know your score immediately, with i-Ready you have to wait.

— Field note 171207: District B, Teacher B

The desire to know how students are doing in real time was highlighted by teachers as well. Teacher B explained that all the other products she used provided detailed, immediate feedback. With i-Ready there were often hours of lag and she did not have access to when students logged on to i-Ready (there was concern about diagnostic testing being done at home), nor did she know what problems students received or how long they worked on them. This need was highlighted during the post-diagnostic test observation interview when observers shared that one of the students received a trigonometry problem:

Observer 1 shows the problem below from her notes:

Question: Which is the equivalent to tan(5pi/6)

Answer Options: tan {-(5pi/6)}, 7pi/6, cot5pi/6, tan(-pi/6)

[Note: potential transcription error in the answers]

Teacher B: It's trig.

Observer 1: Yes! It's trig!

[...]

Teacher B: I find that really interesting, because last year when I was doing i-Ready with my 8th graders I had a large group, 6 or 7 students, that were really mathematically gifted students [...] and some of the high schools are looking for the title in your course that says Compacted Math. Our title says math 8 because I teach grade level. But they already knew ...

Observer 1: They were ready for pre-calc.

Teacher B: They really were. So, one of the frustrations they shared with me was that i-Ready maxes out, i-Ready doesn't give them harder problems. Or if it does it doesn't show me so [...] it is interesting. So if i-Ready is giving them trig questions, what would be helpful would be rather than in my report saying "max score" it said "9th grade, 10th grade" and then this is a report I can print out, give to that parent who can take it to that private school or wherever they end up going, so yeah, they were in math 8, but really this is their performance, beyond just the state test.

Observer 1: Well, the other thing is you could guide her, say hey, here is this [trig] lesson for you. You got this crazy test thing, we don't want to pretend it did not happen, here is where you can learn about trig.

Observer 2: Would you be able to look back at what she did and see that question?

Teacher B: No.

— Post observation interview transcript 120717: District B, Teacher B

As the transcript shows, Teacher B also would like to have more access to what exactly her students are seeing in the test so she can support their learning and their placement in future math courses. Teacher B would like to provide more information to the students and their families about exactly where they are, in addition to SBAC scores. Edtech products share the modern problem of data — how much should be offered up, to whom, and in what ways. As discussed above, i-Ready is an excellent platform at the district level and for researchers to work with. Some teachers feel the reporting is overwhelming as is, yet others like Teacher B crave more detail on what their students' tests look like.

Testing is always difficult for students, and no product is going to solve all the struggle that goes into testing for students. That said, it was interesting to note the postural and affective differences in Nicolas and Walt as they transitioned from the [product] quiz to the i-Ready diagnostic. Both, in their own ways, showed how they were more engaged with [the product] than with i-Ready. Nicolas went from what is often thought of as perfect school posture while doing the [product] test, to trying to disappear under his desk by the third i-Ready question. Walt was positively interactive, jubilant and celebrating (quietly) when he got the award that accompanies correct answers on [the product]. Even when he got an answer wrong, he still went through the hints to figure out why. When he got to i-Ready he became still, almost motionless. While Nicolas might have felt confident and had perhaps studied the quiz material and thus felt more engaged, with Walt it seems that in [the product], even though it was a test, he was still in a learning space. With i-Ready there are no hints and no acknowledgement of whether or not a student solved the problem correctly — the student experience is pure evaluation for evaluation's sake.

Limitations of the Qualitative Analysis

Qualitative research is heavily dependent on the skills of the researchers and can be subject to personal biases. To mitigate these issues, two observers attended each observation and wrote individual field notes. Analysis was conducted to consider all observation points and lift up re-occurring themes.

Qualitative data is also influenced by the type of data collected. In order to create a balanced view of implementation, this study collected numerous types of qualitative data and aggregated themes across the data.

Researcher influence is always an issue when conducting qualitative data collection, particularly when youth are involved. By conducting observations in clusters and engaging as participant-observers, we worked to normalize our presence in the classroom as much as possible.

Finally, the data are limited by the field of collection: two districts close to each other and six classes taught by three teachers.

CONCLUSION

The National Bureau of Economic Research issued a meta-analysis in 2017 of randomized control trials and regression discontinuity studies on technology-based approaches in education. Within a select body of 29 studies on computer-assisted learning (CAL), the research team highlighted two promising models. They suggested that math products can improve student achievement when they provide "customized practice" including immediate feedback to the student or the teacher as a student works through a problem (Escueta, Quan, Nickow, & Oreopoulos, 2017). One of the review's authors said in a blog post about the work, "CAL was most effective when used as an in-class tool or as mandatory homework support, essentially providing personalized tutoring on an individual level" (Quan, 2017).

Our study also showed this to be the case. Students who used i-Ready for more than 45 minutes a week had a significant increase in their standardized test scoring. In our observations, we learned that the students who had time to use i-Ready in class and had access to use it at home (Teacher B's students) used the product enough to have an impact on their SBAC scores.

In this analysis, we discovered that edtech products like i-Ready are not student agnostic — different students engage with them differently to different ends. The quantitative analysis showed that the lowest achievers spent less time on i-Ready than the highest achievers, making them less likely to improve their assessment scores. This is despite the fact that these students often preferred i-Ready to other edtech products. What we discovered is that students need more than the individualized learning that products like i-Ready offer. They need individualized supports to access the benefits that products like i-Ready offer.

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APPENDIX A: w-READY/ READY PRODUCT ANALYSIS

Curriculum Associates, the developer of i-Ready, was founded in 1969 to make classrooms better places for students and teachers. Currently, Curriculum Associates has over 700 employees and is a national brand. Other than i-Ready, it has also created the Brigance Series, CARS/STARS, CAMS/STAMS, Quickword, and Ready. All these products are focused on reading and math assessment or intervention. The products mainly focus on kindergarten through 12th grade. i-Ready is a program that is also math and reading based, so that teachers can diagnose the level a student is at and provide the proper amount of instruction. Currently, over 7 million students use i-Ready and the complementary classroom product, Ready. Five million of those users exclusively use i-Ready, while 2 million exclusively use Ready. Curriculum Associates will no longer offer either product separately. The company discovered that when the products are used in tandem, students are learning more and require less remediation.

According to the Center on Response to Intervention, the i-Ready Diagnostic for Mathematics costs $6 per student for an annual license, which includes online student access to the assessment, staff access to the management and reporting suite, downloadable lesson plans, and user resources. Curriculum Associates also provides onsite professional development sessions for $1400 per session that last three to four hours for up to 30 participants. Live online webinars are also available for a lower cost of $500 per session.

i-Ready has three main components: Diagnostic, Instruction, and Prediction. It is considered an adaptive software in which, through computer analysis, the program is able to predict a student's current level and what supports are needed. The diagnostic test uses an algorithm through which the correct or incorrect answer to a question will determine the next question the student receives. If students answer a question correctly, then they will get a more difficult question next. If students answer the question incorrectly, then they will get a question that will be easier. Typically, students spend 45 to 60 minutes on the diagnostic test, and each student ends up getting 50 percent of the questions correct, no matter the level. Students take the diagnostic three times a year consisting of 72 questions.

The instruction is based on how well students performed on the diagnostic. Students can be more advanced or less advanced; however, the program determines where the student is placed so they optimize their use of the software. All activities are Common Core–aligned so teachers can better identify the needs of their students and focus instructional time on those areas of growth. In math, assessment and instruction emphasize conceptual understanding as well as procedural fluency. There are four areas in mathematics that are covered: Number and Operations, Algebra and Algebraic Thinking, Measurement and Data, and Geometry. Many of the tasks draw on content that students have learned so they are able to make connections between math concepts. i-Ready also uses cross-curricular concepts on which to base stories or problem. i-Ready strives to create an educational program that is enjoyable and educational.

In order for teachers to use the program most effectively, Curriculum Associates recommends three to five touchpoints per year in which teachers receive professional development on how to implement, analyze, and utilize the program. In the first professional development session, teachers learn how to obtain good data and how to administer the first diagnostic test. This professional development session generally happens in the summer before the test. The second professional development session is a month after the first diagnostic, and in this session teachers learn how to use the data from their students in their classroom. Then the leadership team has a professional development session on how to use all of the data from the teachers in their school to understand their current levels and support a student growth plan. The fourth and fifth professional development sessions include coaching and modeling for teachers by Curriculum Associates staff. (Curriculum Associates does not believe in the train-the-trainer model, as they believe it is less effective and does not get the message across.) This would typically include a six-hour day with individualized sessions. Curriculum Associates used to sell the i-Ready license whether or not the district or school agreed to professional development; however, Curriculum Associates does not offer that option anymore. If the licenses are purchased, then the schools have to agree to some professional development, because Curriculum Associates wants the program to be used as effectively as possible.

When teachers log in, there is a screen where they are able to see the results from their most recent diagnostic test, the instructional progress of their students, and the performance and growth of their students between diagnostics. There are also six tabs at the top of the screen: Home, Roster, Settings, Assignments, Reports, and Resources. When analyzing the diagnostic test, the teacher needs to select the academic year, the way the students need to be organized, the class, and what "on level" means. They click "run report," and the readout is organized by Overall Math Level, Number and Operations, Algebra and Algebraic Thinking, Measurement and Data, and Geometry. The teacher observes the class's overall performance, and then they can see the performance of each student. Again, the program shows where a student is overall based on grade level, and then the program breaks down each category mentioned previously. The teacher is able to use this information to determine what each student needs. Teachers are also able to see their class norms, where it displays each student's quantile measurement and the percentile, and where they fall in according to their grade level. It is broken down into on or above grade level, at or near grade level, and one or more levels below grade level. i-Ready provides a report on the targeted growth rate of the class as well as the students. It provides tangible goals for the students to meet based on data that it has analyzed.

Once the teacher determines the level of the class and the level of the students, the teacher can begin the instructional plan. i-Ready also provides reports on the progress of the students and how much time they have stayed on task. Teachers can get a weekly breakdown of the amount of time a student has worked on i-Ready as well as the amount of time the student stayed on task. They can also download a report on the class response to instruction that provides the lessons completed, lessons passed, pass rate, number of lessons in progress, and the time on task. It shares this information for the class and for individual students. This way, a teacher can assess the needs of each student and determine how best to help that student meet those needs.

Teachers can set up their roster in the teacher dashboard. If the district uses an SIS that communicates with i-Ready directly, rosters will be imported automatically. If not, the teacher can add a new class and the program will generate a list of usernames and passwords for the students. Teachers can also create instructional groups where they can cluster or group students based on ability or another factor that they determine.

The assignments page has four tabs that can be used: Class Management, Diagnostic and Growth Monitoring, Lesson Plans, and Extra Lessons. In Class Management, the teacher can add or remove diagnostic tests or add or remove additional growth monitoring tests. In the Lesson Plans tab, the teacher can add or remove lessons that are planned for each student based on the needs of the student. The teacher can also add extra lessons to the scope and sequence if the teacher feels it is warranted.

Curriculum Associates has completed several case studies to prove the effectiveness of i-Ready in the classroom. The first case study was completed at PS 1 Courtlandt School in the Bronx, New York. It is a Title I school with 698 pre-K through 5th grade students. Ninety-eight percent of the students are eligible for free or reduced lunch and 20 percent are English language learners. The study looked at 340 students in the 2nd through 5th grades for 14 weeks between the first and second diagnostic tests. The study found that there was a 143 percent increase in students at or above grade level in math based on the diagnostic tests that were given and the instruction they received from the teacher. One of the key factors that led to high success was parent or home involvement. Parents received i-Ready reports on a regular basis, which increased i-Ready practice at home.

Another case study was written based on data and observations from Farmington Elementary School in Culpeper, Virginia. It is a Title I school with 495 kindergarten through 5th grade students, 52 percent of whom are eligible for free or reduced lunch. Students used i-Ready 30 to 45 minutes per day, 4 to 5 days per week, for fewer than 18 weeks. Three hundred and seventy students were analyzed, and most were struggling with math, reading, or both. There was a 260 percent increase in students at or above grade level in math. This was attributed to the report readouts that i-Ready provided to the teachers so that they could have relevant discussions with the students about their progress or current level in math.

i-Ready's diversity of reporting on individual students to assist the educator in personalizing education for their students is one of its greatest strengths. To make the i-Ready program successful, constant communication with the parent and student to update them on their levels and where they need to improve is required.

Both case studies highlighted reporting as a key factor for success. The adaptive qualities of the diagnostic test and software help determine the accurate levels of each student. The amount of information that can be shared with a teacher, school leader, or district leader is large and can provide a snapshot of the class. As with any piece of technology, the program seemed as effective as the educator using it. The schools that were showcased had involved educators who went out of their way to discuss achievement levels with parents and students alike.

The Center on Response to Intervention at the American Institutes for Research performed a comprehensive study of i-Ready's math platform. i-Ready was graded based on six main factors: Classification Accuracy, Generalizability, Reliability, Validity, and Disaggregated Reliability and Validity Data. i-Ready performed at the top level for all five categories. Classification accuracy refers to a predictor of how well a student will do on the SBAC and if they will qualify as "at risk for math disability." Generalizability is the extent to which results generated from one population can be applied to another population. Reliability is the ability of the tool to classify students regardless of the administration or environment of the school. Validity measures the underlying idea or purpose that a product is intended to measure.

APPENDIX B: QUANTITATIVE METHODOLOGY

The two school districts in this study give students access to the i-Ready technology for interim assessments in English language arts and mathematics, and to learn or review grade-level topics.

In these two school districts, all students in the 3rd through 8th grades take three interim assessments during the school year. The first one is at the beginning of the school year, the second is before the end of the fall semester, and the third is during the early spring semester before the state assessments. The interim assessments provide the opportunity for the school district to understand the level of their students and how they progress throughout the school year. i-Ready also provides students targeted lessons based on the interim assessment. For example, students who meet the standards on a math topic can learn new lessons and students who are not meeting standards on a math topic get to review the topic with targeted lessons. This study focuses on math study lesson time on i-Ready.

Curriculum Associates, the developer of i-Ready, recommends students use the product for at least 45 minutes a week. To begin, we tested if student time on i-Ready lessons correlated with SBAC achievement levels. The data set contains a wide spread of lesson time usage that ranges from one minute for the whole school year to more than 60 minutes per week. In examining the type of students who use i-Ready, we observed variation by achievement levels. To find whether the average mean differences between achievement levels are significant, we conducted a regression analysis.

Regression Model

- **Dependent variable:** Total lesson math time on i-Ready
- **Independent variable:** A categorical achievement level — Levels 1 (standards not met), 2 (standards nearly met), 3 (standard met), and 4 (standard exceeded).
- **Covariates, which include:** female (female or not), special education status (in special education or not), English learner status (English leaner or not), and ethnicity categories (Asian, Latino, White, and Other — Includes African-American, Native American, More Than One).

Methodology for Impact Evaluation

A matching analysis design was used to evaluate the impact of the i-Ready technology used in the classroom within two school districts (Rosenbaum & Rubin, 1983; Imbens, 2015). This included, analytically matching students using i-Ready for a certain time-frame “treated” group) with similar students who used i-Ready for less than the specified time frame (the “control” group). The analytic matching is based on the Mahalanobis distance metric, which is the distance between the covariate vector *x* and *x'*: $||x, x'|| = (x - x')\Omega_x^{-1}(x - x')$ where Ω_x is the sample covariance matrix of the covariates (Imbens, 2015). In the matching analysis, each “treated” student was matched to the two closest “control” students (“nearest neighbors”), so that the matching was conducted “one-to-two.”[9]

The following variables were used to match treated students to similar control students: grade 6 Smarter Balanced Assessment Consortium (SBAC) mathematics scale score, first interim assessment scale score, gender, ethnicity, English learner status, and special education status. The student ethnicity categories used were Latino, Asian, White, and Other. The Other category included African American, American Indian, Native Hawaiian or Pacific Islander, and Two or More Races.

After each treated student was matched to the two closest control students, all of the matched students were included in an ordinary least squares (OLS) regression model that included the same variables as covariates that were used in the matching process. This made the evaluation more robust in that the matching and the regression protect against misspecification in either model (Imbens & Wooldridge, 2009). Previous studies have suggested that matching on a set of baseline data that are strongly predictive of the outcome measure and then using regression methods on the matched sample can succeed in replicating experimental impacts in certain contexts (Cook, Shadish, & Wong, 2008; Gill et al., 2013). The following is the regression model:

$$Math7SBAC_i = \alpha + \beta_1(Treated_i) + \beta_2(Math6SBAC_i) + \beta_3(MathInterim_i) + \beta_4(Ethnicity_i) + \beta_5(Female) + \beta_6(ELL_i) + + \beta_7(SPED_i) + \varepsilon_i$$

Math7SBAC$_i$ is *i´s* student grade 7 SBAC math scale score, *Treated* is a binary variable indicating part of the students using i-Ready for 45 minutes or more, *Math6SBAC* is the grade 6 SBAC math scale score, *MathInterim* is the first interim assessment taken in the first semester of grade 7, *Ethnicity* is a vector of dichotomous variables indicating student *i´s* ethnicity (Latino, Asian, White, Other), and *Female* is a binary variable identifying female students. α is the intercept, β_1 – β_7 are parameters to be estimated from the data, and ε is the independent and identically distributed error term.

β_1 ⊠ in the above equation represents the average difference in grade 7 SBAC math scale score between the treated and control students after controlling for the covariates included in the model. This represents the impact of the i-Ready technology.

Due to the difference in the number of minutes of i-Ready used by students in different achievement levels, three separate analyses with the same analytic design were conducted. Each analysis included one time frame: 15 minutes or more, 30 minutes or more, or 45 minutes or more. For example, for the 45-minute analysis, the treatment included using i-Ready for 45 minutes or more. Those students using i-Ready for 45 minutes or more were placed in

9 The baseline equivalence was achieved after the first match and there was no need to refine the analysis to reach baseline equivalence.

the “treated” group, and students using i-Ready for less than 45 minutes were placed in the “control” group.

Two additional estimates were conducted to understand the impact of i-Ready usage. One focused on the growth to the next achievement level and the other focused on the growth within the achievement level. Both of the analyses were conducted for the treated and control group.

The growth to the next achievement level was computed for the 45-minute and 15-minute analyses because students stayed within one achievement level. This growth helps us understand how far the students have increased toward the next achievement level. The growth was computed as follows:

> The percentage gain = growth / (the cutoff of next achievement level — the estimated mean scale score in grade 6)

The growth within the achievement level was computed for the 30-minute analysis because students moved from achievement level 2 to achievement level 3. This growth shows how far students have moved within the next achievement level. The growth was computed as follows:

> The percentage gain = (the estimated mean scale score of grade 7 — the cutoff of the achievement level achieved) / (the scale score difference of the achievement level achieved)

APPENDIX C: QUALITATIVE METHODOLOGY

Focus Group Guide

Procedures: 2 audio recorders per group

Make sure to count how many students you have.

Time total: 37 minutes	Item	Probes
5 minutes	Introduce focus group concept and get papers back to sort	
5 minutes	Logistics of FG: no over-talking, read ground rules (should we use sentence starters??) During this time, sort out the groups by interest.	For the examples: What do you see in Hector and Maya's responses? Which response do we want to aim for?
5 minutes	Intro: Okay, we are going to ... Tell me your full name and your birthday	
7 minutes	Warm-up	Math and product generally — what is the student's relation-ship to math?
7 minutes	Product-specific	Does this product support them? Why or why not?
7 minutes	Scenario	What if they had more control? What would happen?

Warm-up (7 minutes)

1. What part of math class do you think helps you learn the most?
   a. What part of class works for your learning?
      i. Small group? Talking with other students? The computer programs?
      ii. What are the different things you use?
      iii. Do you use a text book? What one? How often? What else do you use? Worksheets? Or what else does Teacher A assign?
   b. Okay, of all those things (mention them), what do you enjoy doing the most?
      i. Could mention each one and ask students to raise hands, just make sure you describe how many hands for each of the ways

2. Why did you choose to talk about the [insert program name]?
   a. So, we're here to talk about [product]. Why do you want to talk about this one instead of the other?
   b. When do you choose to use [product]? How do you decide?
   c. Do you ever use the product outside of class? At home or in an afterschool program?

Other ideas/things to test and perhaps figure out how to word for the conversations

- How are the products similar to or different from working with the teacher? Textbook? Worksheet?
- How do they feel about the testing (particularly in i-Ready)? Do they experience getting things incorrect that they feel like they already know?

Teacher Interview Protocol

School General:

1. What is the structure of Adventure STEM? How does this influence your classroom?
2. Is there any tracking? Grouping?

Technology General:

3. How would you describe the structure in your classroom?
4. What role does technology play?
5. What are the expectations for home use of devices and internet?
6. How do the products you use fit into your structure?
   - What are all the tech products you use to teach?
   - Are there other websites or products you use for planning?
7. When did you start using technology in your classroom? What was your first tech?
8. How did you arrive at your current structure? How did you choose these technologies?
9. Laptop logistics: How many students use one computer? How does the login/logout process work for them?
   - What sorts of supports were provided?
10. District training? Dedicated PD days? Collaboration with others in your department?

Technology and Instruction:

11. How do you feel about the use of various technologies? How have they impacted or influenced your teaching?
    - What would you tell another teacher who was going to start using it?
    - Are there any features of the product that stand out for you?
    - What impact does it have on your planning?
12. How do you feel the use of i-Ready has impacted or influenced your teaching?
    - What would you tell another teacher who was going to start using it?
    - Are there any features of the product that stand out for you?
    - What impact does it have on your planning?
13. Are there any technologies or products you wish you had in your classroom?

Technology and Students:

14. How do you think your students feel about the products you use in the classroom? Why do you think this? Can you describe a moment that shows this?
15. Do these products support your understanding of your students' math ability? Why or why not?
    - What sorts of diagnostic or evaluative tools do you utilize from the products?
    - For specific tech (Google Classroom, Khan, i-Ready)

- We noticed that the students hesitate to use the hints or videos on Khan because of the scoring — what do you think about that?

16. When you think about the math proficiency of your students, do you see any sort of variation in their use of the technologies?
17. Thinking about specific students (current or former), can you describe how the products have supported or hindered their math knowledge?
18. Do students access any of these technologies outside of the classroom? How do you know? Is it part of their homework responsibilities?
19. Do you have a sense of what your students' access to the internet at home is generally? Do they have other resources, either through afterschool programs or libraries, to access online class resources?
20. What sorts of technical support do you have access to regarding infrastructure, hardware, or software?

Classroom Observation Purpose and Protocol Overview

Parts 1 and 2 to be reviewed before each set of observations

Research Questions 5 and 6

1. How do teachers implement use of the product?
   a. Does the product support teachers to create a personalized learning experience for students?
   b. When is it used — during class or as homework?
   c. Is the product used in a standalone method, or is it integrated with other lesson materials?
   d. What sort of time and effort does it take on the part of teachers to use the product? What are the supports for and barriers to use of the product?
   e. How does the teacher see the product — is it a benefit to her students? Does it support his instruction?
   f. With what frequency and for what duration do teachers assign or direct use of the product?
   g. Do teachers engage caregivers with the product, and if so, how?
2. How do students engage with the product?
   a. Do students show or report feeling a sense of agency and self-direction in their use of the product?
   b. When and where do they use it? If they use the product at home, are there any other adults or siblings who are in some way connected to that use?
   c. What are the characteristics of use for students who see the greatest gain in mathematics performance? The least gain?
   d. Does engagement and use of the products vary at all along demographic variables? Along math achievement variables?
   e. What are the positives and negatives of the product, according to students? What do they find useful? What would they change? Do these opinions change over time?
   f. With what frequency and duration do students use the product?

Personalized Learning

From Bill and Melinda Gates Foundation website:

- Allowing teachers to determine what a student doesn't understand so that they can better target interventions to help students get back on track
- Simultaneously help multiple students who may be at different levels of mastery so that students can progress through content at their own pace without worrying about being too far behind (or ahead) of their classmates

» Enabling students to take ownership of their learning and understand how they learn, so they can be better equipped to take action, set goals, and determine what support they need

From Leap Learning:

1. **LEARNER CONNECTED** Learning transcends location in relevant and valued ways, connected to families, educators, communities and networks
   a. **Learner Connected: Anytime, Anywhere and Socially Embedded** Learners collaborate with peers, family, educators, and others; cultivate meaningful relationships; advance personal opportunities through connections; engage in real-world experiences to develop academic knowledge, community engagement, workplace experience and global citizenship; and earn valued recognition for all demonstrated competencies (regardless of where and when it happens)
2. **LEARNER FOCUSED** Empower learners to understand their needs, strengths, interests and approaches to learning
   a. **Learner Focused: Tailored Learning Experiences** Learners develop a deep understanding of needs, interests and strengths around academics, health & wellness, social-emotional development, culture & language, living situation, and cognitive skills; and they experience learning that is relevant, contextualized and designed for their individual needs, interests and strengths.
3. **LEARNER DEMONSTRATED** Enable learners to progress at their own pace based on demonstrated competencies
   a. **Learner Demonstrated: Competency-Based Progression** Learners begin at a level appropriate to their prior knowledge and learning needs; engage in productive struggle; progress at a pace that fits their learning needs; demonstrate competency when ready; demonstrate evidence of learning in multiple ways; and receive recognition based on demonstrated competency, not seat time.
4. **LEARNER LED** Entrust learners to take ownership of their learning
   a. **Learner Led: Learner Agency** Learners co-design their learning experiences; articulate their interests, strengths and needs; assess, monitor and reflect on their own progress; partner in setting their learning goals and plans; and advocate for support from teachers, peers, technology and other sources

Classroom Observation Checklist

What happens: Observations by a team of two researchers during mathematics lessons when the target technology is in use. Observers will take notes during the lesson and gather evidence for ratings. Afterward there will be an hour to hour-and-a-half time for completing notes and consensus discussion.

For each observation set:

1. Obtain seating chart
2. Note members of all small groups (for comparison over time)

Pre-observation:

1. Review teacher lesson plan and work through component of the product planned for the lesson. Make sure to understand the math content of the lesson.
2. Confirm observation day and time with teacher, 48 to 12 hours prior to observation.
3. Try to schedule post-lesson debrief (10 to 15 minutes, can be done over the phone but ideally directly after period).
4. One of your team members should make sure that you have $25 gift cards for teachers you will be observing.

Forms to fill out post-observation:

1. Individual ratings with specific evidence from class (e.g., not "lesson fulfilled the

requirements for High rating" but "Bobby said X and teacher responded Y").

2. Consensus ratings and consensus lesson summary. If you had different individual ratings and had to come to consensus, provide relevant evidence and reasoning on the consensus form.
3. Summary form

Teacher Pre-Interview Questions

(possibly done online beforehand)

1. What are your overall goals for this lesson? Any particular standards targeted?
2. How do you envision the role of the product in the lessons? What will it enable the students to do?
3. Think back to when you were planning this lesson — did you feel that you had to make any tradeoffs? What did you emphasize and what did you leave out for today? Why?
4. What student responses, reactions, or roadblocks are you anticipating for today? What strategies do you think you will use to address these as they arise?

Teacher Debrief Questions

(this would be done in person)

1. How was the lesson instruction from your perspective?
   - Probe: What worked? Describe to me how you knew, what did you see in your classroom and your students? Were there any sticking points? How did you know? What were your students doing that showed you the lesson was sticking?
   - Probe: Do you think you will change this lesson next time? How?
2. What do you think your students learned from this lesson?
   - Probe: What did you see as evidence of learning?
   - Probe: What did you see as challenges students encountered?
   - Probe: What further assessment might you consider?
3. What about the product?
   - Probe: Supportive of teaching and learning?
   - Any challenges in using it?
   - What changes have you made over time with this lesson, this product?

APPENDIX D: SAMPLE FIELD NOTE

All names have been replaced with pseudonyms. Field notes followed this format but varied in length and depth depending on the observation.

Field Note: XXX171010sm1

Observer Author: Stacy Marple

Other Observer: Justin Sewell

Summary

Overall this day showed i-Ready at its worst — it was confusing, challenging to even enter the numbers that they wanted to enter at times, and completely thwarting any type of collaborative activity. Furthermore, it was clear that the students were struggling with the vocabulary that i-Ready was using, and there was no spot for them to get further information on the words.

In contrast, this day also showed the incredible tenacity and general good mathematical attitude of the students. They were willing to talk though confusing problems, were determined to work together, and sincerely wanted to get to the right answer — despite the fact that random clicking seemed to get the students the furthest.

Three focused observations here — on struggling with vocabulary, on collaboration, and on how the program will shift problems without supporting students to understand why. To try to capture the collaboration, struggle, and confusion, extensive transcription is included here.

Observations, General

I got into the classroom just past 8. Students were in before school hours to work on homework. Teacher A was at a cluster of desks in the front of the room working with Matt and a few other students on the distributive properties of algebraic equations. Three girls near the door (Danielle, NP, and Ariana). They were stuck on question 90 — it asked them to rephrase the equation and then write it out in tiles. They asked for help, and Teacher A then asked if I could go over. For the next ten minutes we worked on how to reduce and reform equations. At the end Danielle was able to explain to the two other girls how to change $12x + 18$ to either $3(4x + 6)$ or $2(6x + 9)$. And then they all independently reduced $10x + 15$ to $5(2x + 5)$ quite quickly.

The students moved quickly into their stations as class started. There was a desk in the left corner of the room with a soft office-style high-backed seat in it that faced out toward the room. Jasmine sat in it and Danielle called out, "You not allowed there." Teacher A immediately asked her to move, and Jasmine complained to the class about how Danielle called her out. It settled out at the computers as such from left to right: Jasmine, Ignacio, Danielle, Audrey, Ariana, and NP boy.

As Jasmine moved from the office-style chair to a regular school one, Teacher A asked Audrey where Danielle was, if she had texted her to come to class. Audrey said Mrs. (?) had taken away her phone, so she could not text Danielle.

Justin sat down with Jasmine, and I stood behind the three girls watching them start up the program. They started up quickly and without trouble, but they spent some time working at untangling headphone cords. We joked about what a hassle the headphones are, and then I noticed that Danielle did not have any. I offered her mine, in exchange for letting me listen in on one headphone occasionally. The other girls said, "Aw, that's nice," and looked up at me with wide eyes.

The three girls and Ignacio were all in the same algebra section I had seen the day before. At first, they had the "estimate screen" where there was a dial on a vault, and they moved to select different numbers to solve the equation. At one point Ignacio (3:33) is trying to get past the estimate screen. He gets past and I say, "I have no idea what happened there." He laughed and said, "Me neither, I was just clicking buttons." Once they solved it, the vault opened, and they had the same problem but were asked, "Using the principles of equivalency and inverse operations, isolate the variable" (I knew this because I listened in to Danielle's screen — the words were only there while the character was reading them).

The first task on the problem was to select the operation to do to both sides that would isolate the variable. There were no hints, they just kept clicking until they got the correct operation.

Then they were asked to figure out what number to use with the operation on both sides to isolate the variable. As they entered different numbers the program progressively continues to do that math but does not keep all the math visible. This creates the sense that they keep getting new problems, rather than continuing to work through a single problem. At one point Audrey guessed too many times, perhaps. And then she is just given a truly different problem, no relationship to the previous one she had been working with, but also without a clear indication that it was a new problem.

About midway through the class Danielle and Audrey try to work together, and Ignacio and Ariana also chime in; however, the program does not leave many crumbs or much of a map for students to help coordinate with each other. Rather, they end up restarting the module each time one of them does something different so they can be on the same screen.

It's a short day, and the class ends before the girls are able to get to the next section of work, on reducing complex equations, that is similar to their homework.

Observations, Focused:

1. **Listening to the algebra problems with Danielle (5:40):**

I see the penguin come on Danielle's screen and ask, "Can I listen in? I saw that penguin all day yesterday, and I have no idea what he said."

It introduces the problem saying, "Using the principles of equivalency and inverse operations, isolate the variable," and then puts up the screen where the student needs to choose what operation to use. I watch as Danielle clicks through the operations and ask her, "Do you know what it is asking you?"

She says, "Umm, not really."

S: "Well, what does it mean when it says isolate the variable?"

D: "Subtract?"

S: "No but, um, what does isolate mean, do you know what isolate means, the word?"

D: "No."

S: "Do you know island?"

D: "Yeah."

S: "It's like, island, it is all by itself, right?"

D: "Oh."

S: "So you want to get that m all by itself, that is what isolate is."

2. **Trying to collaborate on i-Ready: 140 = m + 80 (8:40):**

The girls are all on the same screen for a moment and are looking over at each other's computers. The problem is 140 = m + 80. The task is to isolate the variable by subtracting from both sides. I notice them looking at each other's screens, and comment on the fact they are all on the same problem. They try out possible answers and talk to each other about them. However, they quickly discover that the same number does not seem to work as an answer for everyone. Since I am watching all the screens, I notice that what has happened is that they started on the same problem, but as they enter numbers to try, i-Ready calculates using that number, and then has them continue with the problem, in the way that the number they entered altered the problem. The screens move very quickly, and the original calculation is removed. As a result (see conversation below), Danielle, who is moving the quickest, asserts the answer is 20. What she did is as follows:

Types in subtract 40 from both sides. The work is shown:

140 = m + 80

-40 = -40

100 = m + 40

Then it clears all this work and puts at the top of the screen

100 = m + 40

Danielle enters 20 and it shows m = 60. However, since she entered 20 as the last number in the box, she asserts to her classmates that the answer is 20, 20 is the number to put in the box. Audrey is skeptical and takes the calculator and begins doing the math. She thinks the number to put in the box is 60. Ignacio enters the conversation, and also states the answer is 20. When Audrey shows on her screen that the answer is 60, Ignacio expresses confusion, saying "huh" and looking to me and to the screen. Ariana, who already finished the problem and has a new one up, enters the conversation saying she entered 60. Danielle finally puts in 60, but she has already done 20 one time, so it comes out as a negative number, and clearly incorrect. Ignacio again expresses confusion. He backs out of his screen and goes to start again. Danielle tries to explain the difference by saying that she was ahead of them, but again Audrey is skeptical and asserts that they are all on the same problem.

See conversation below:

Transcribed from audio recorder
I: I think it's 60.
S: This is really interesting because you all have the same …
D: Try 20, try 20.
A: Huh?
D: Just do it, try 20, try 20.
A: I'll get it wrong then. (takes the calculator)

D: It's mine.
A: I know.
D: Try 20.
A: It's 60.
S: (to D) Was 20 the first thing you tried?
D: Yeah.
S: Or was it the last thing you tried?
A: No because its 60 plus 80 equals 140.
D: Ooh.
A: No because if it was 80 plus 20 it woulda been 100.
D: Ooooh.
I: It's 20.
A: It's 60.
I: It's 20, it's 20.
Al: Put 60.
A: I did it, look Danielle.
A: [pause] Just put 60.
I: What the heck?
I: Well, she [Danielle] put 60 and she didn't get it right.
A: I got it right, but she didn't get it right.
Al: No, I did, I did 60 here.
A: I did 60 and I got it right.
I: Man, it's true. Wait whaaaaat?

Al: Well how come, how come she got 20?
D: Well I think maybe, I think I'm like one step ahead of you guys
Al: No, you're on the same thing as us.
S: How could 20 be an answer? How would 20 be part of the answer? What else would be part of the answer if you know 60 works?
I: I don't know, 20 and 60 works.
A: That's 60 because 60 + 80 =140.
D: But 20 was an answer.

I walk over to Ignacio as he hits the back button, trying to get to the same place the girls are — however, he ends up back at the beginning of the module, not at the last screen he saw.

He begins with the dial (the estimation screen) and keeps passing the dial left and right, left and right, trying to get it to land on the number he wants. I comment that it seems really annoying and ask if there is another way to put in the number. He says no, and laughs saying last time it took him 2 minutes to get it where he wanted it. I encourage him to try the answer he believes to be correct, 20. When he did not get the "bing" saying that he got the correct answer, and instead saw a screen that asked him to do a new problem, Danielle tried to explain it by saying he used multiplication. I tried to show her how it had already done the subtraction. How the program "remembers it." This led Danielle to wonder if Ignacio had gotten the problem wrong. I tried to explain to her that he had not gotten it wrong, but rather had to do it in two steps. The conversation is below:

I: It took me so long.
I spent like 2 minutes doing that I was like ugh.
S: Oh yeah, the dial.
S: Okay, so try 20 here, okay, come on bird, busy with your talking ...
[wait a minute or so while bird talks]
S: Okay, so let's try. You got the subtraction. So do 20 and hit enter. Okay, so now it tells you to try again, right?
D: It's because he chose multiplication.
S: No, he chose subtraction. See what it does, it holds, as if you have already subtracted the 20.
D: Oh yeah.

	S: See, it remembers it, so then it's almost like the 20 works.
	I: So, 60 is the correct answer.
	D: Did he get it wrong?
	S: No, but he had to do it in two steps instead of one.
	I: No, I got it, it was like boom baby. It says that sometimes.

3. **Ariana works on the estimation of m for 15 = m3**

Below transcribed from audio:

S: How would you reverse it?

S: What is the opposite …

Al: Of 3?

S: No, what's the opposite … function?

Al: Multiplication?

S: Multiplication, right. So how would you reverse it to figure out …

Al: Oh, um, 3 x 5.

S: What's that?

Al: 15?

S: Try it?

M [messes with the dial, it takes a while to get it to 15]

S: So, whenever you have a blank, think about the opposite operation. Usually whenever you have a variable you need to use the opposite …

Al: Operation.

S: Yeah.

Al: Thank you.

4. **More collaboration with 140 = m + 125 and challenges with vocabulary**

After a few minutes of watching the whole group I notice Danielle struggling with the 140 = m + 125 problem. I ask her what the problem is asking, and it is clear that she does not remember what isolate means. I try to remind her about the mnemonic of island and before I can tell if she is with me or not, she hits the back button. Now she, Audrey, and Ignacio are all on the same screen. They begin talking about what numbers they could try. Mostly they are trying to solve form and suggest using 15. Since they have gone down this road a few times, to no avail, I encourage them to keep thinking about what the problem asks. Danielle is on the calculator and Ariana tries a few numbers quickly before I can follow exactly what is going on. All of a sudden the program gives her an entirely new, simpler problem: 30 = m + 15. She gets the answer for this one, but in her description, she did not seem to isolate the variable. Rather, she solved for it.

17:20

S: What did it tell you to do? To make it equal or did it tell you to put something on an island. Was it telling you isolate here?

D: Uh, no.

S: What did it say?

D: Type the number that should be subtracted from both sides … [pause]

S: To what? [pause] Did he use that word like island? Isolate?

D: To isolated …

S: Yeah, so what did we learn about isolate? The island? [pause] Islands are what?

D: Isolate the variable.

S: Islands are what?

D: By themselves so isolate the variable.

S: So, put that variable on an island by itself. Isolate. Island. So, what are you guys to do in your subtraction … oh now back to the estimation again!

D: I just went back to (points to Audrey)

S: Oh, to hers, okay, so you have the same numbers [looking over at Ignacio] Oh! So, you are all on the same now.

S: Okay so how, how do we get that m by itself? We know we are using what operation?

I: 15.

A: Yeah, 15.

S: Wait, we want to use what operation? Let's start with the operation.

D: Subtraction.

S: Okay, subtraction. Now how do we get the m alone, what is next to the m?

D & A: 125.

S: 125, yep, that is next to the m and we want to get the m by itself. [pause]

S: And we are using what?

D&A&I: Subtraction.

S: How do we get that m alone?

A: By subtraction.

S: What are we going to subtract?

D: 125.

I: Or 140.

S: Yeah, sure, dunno. You gotta try.

A: [enters 15, gets the new version of the problem]

S: Okay, so 15 did not work. Now what is next to the m?

A: 110 [then goes back to the estimation screen]

S: Ah, you went back.

A: Yeah, just to be the same.

S: Okay, so get it on the island, there are no other numbers next to the m on the island. (19:27)

[Long pause of about 1 minute of students working on paper, and then trying numbers. A. tries three different numbers.]

S: Whoa, it gave you a whole new problem! Is it asking you to isolate the m again?

A: Yeah.

D: How did you get that?

S: (softly) Just gave her a whole new problem.

A: I put 120.

S: Okay, whoa, why'd it go away so fast … okay, how did m get alone there?

A: Well, um, because so the first one I put 110. And then it gave me another problem and I put 30 on one side and 15 and the m on one side so I subtracted 15 on both sides because then it would be 15 on both sides because 15 x 2 is 30 and 15 and 30 30 — 15 is 15 and so I think it would be equal and m = 15.

REFLECTION:

Overall I felt much more comfortable in the class today, and I felt the students were more comfortable with me — although I think this was in part because I helped out with homework between 8 and 8:25. In particular I worked with Danielle and Audrey in homework, and then at i-Ready time it let me feel comfortable enough to see about sharing the headphones with Danielle. This was critical to my understanding of the challenges the students were having. It was great because I learned that the penguin says critical things for the problems, and much of it is confusing to the students. Furthermore, there is no support to solve that confusion. For instance, a lot of the vocab (like the word isolate, as in isolate the variable) was unknown to them. I tried to create a mnemonic for them (always a bad shortcut, they should make their own ...) — isolate sounds like island, so put that variable on an island by itself — but it did not stick that well — unsurprisingly. This is a serious flaw in the program, this assumption on language. All these students seem to be quite competent English speakers; however, I don't know where they test on the EL spectrum — Spanish seems to be a common home language. At any rate, I can't imagine what i-Ready would be like for any students classified as EL!

Also, the math seemed confusing to me and the students. Part of this had to do with the absolute lack of crumbs, the quick calculations done, and the speed with which they leave the screen. This coupled with the inability to reverse steps, to try again the same thing, made it really unclear as to what was happening or what the "answer" to the problem or even the process of the problem was, as is evident in the conversations around the problem. Often, because i-Ready takes away the original calculation, they do not understand that they are still working on the same problem. The result is the students all think that different numbers are *the answer* to the same problem, because they hold the last number they put in, the one that gives them the bing of approval as *the answer.*

Finally, if the students had not begun collaborating (or trying to) *and* Danielle had not let me share her headphones, I would have had no idea how to understand what the program or the students were doing.

I now really need to spend some time learning what best practices are in teaching this type of algebra. While I can say that, for sure, the program's lack of transparency and short memory cycle (i.e., how quickly the arithmetic is removed from view) creates confusion, I do not have the knowledge to assess if it is a bad implementation of good principles or just generally flawed.

I was *so* very impressed with the tenacity of these students in the face of confusion. Also, with their impulse to collaborate — it is clear they have excellent student skills. I do have the sense (though no solid proof) that they would not have had such tenacity were I not there to support them. This is perhaps most evident in the end of focused observation, where after Audrey gets the "wrong" answer by entering a bunch of numbers, she ends up at a spot with just a simpler version of the same problem that she can answer correctly but without actually doing the work of the problem.