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Exploring Promising Practices in Math Personalized Learning Software Use Among Educators Identified as Positive Outliers

THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

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THE UNIVERSITY OF UTAH
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Bridging Research, Policy, and Practice

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Summary

Although recent meta-analyses have linked the use of educational technology to positive mathematics learning and achievement outcomes, much more work is needed to understand how math personalized learning software is being implemented in Utah's classrooms and to identify the specific implementation practices that are most clearly associated with positive teacher and student perceptions of the software and with positive student mathematics attitudes and achievement for different learners in different contexts. To begin to fill this gap, the Utah Education Policy Center (UEPC) identified educators who, over a three-year period, were in the top 25% of educators in the state on *both* a metric of software engagement (i.e., mean number of minutes students in their classrooms used the software each month) and a metric of achievement (e.g., mean student growth percentile or percent of students proficient in math). These "positive outliers" and other educators were invited to participate in data-gathering sessions at the STEM Best Practices Conference hosted by Utah's STEM Action Center in June 2022. The goal of these sessions was to expand our understanding of promising implementation practices for math personalized learning software as well as barriers to and needed supports for effective implementation.

Educators who were identified as "positive outliers" reported that they viewed math personalized learning software as an important contributor to student success and indicated that they used the software to gauge student understanding and to provide data-informed, tailored instruction and opportunities for practice. Importantly, these educators expressed a commitment to creating classroom cultures in which high levels of accountability are paired with high levels of care and an explicit focus on building student confidence. Data gathered from these educators combined with a review of a still-nascent literature on technology-mediated personalized learning offer myriad promising practices for effectively integrating math personalized learning software use with research-informed principles for strong mathematics instruction (National Council of Teachers of Mathematics, 2014; ULEAD Education, 2021) to create strong blended learning environments. Promising practices include the following:

1. Educators should use math personalized learning software as a supplement to and support for strong, evidence-based teaching practices not as a replacement.

2. Educators should have clear goals for using math personalized learning software, and they should share these goals with students and families. Competency-based goals may be more effective than time-based goals.

3. Educators should use data from math personalized learning software to inform and personalize their teaching in "real-time."

4. Educators should experiment with how to effectively use math personalized learning software in ways that both take advantage of the strengths of educational technology (e.g., to provide immediate feedback) and build upon their own pedagogical preferences and skills. Effective strategies may include grouping students to promote

As gaps in access to educational technology in Utah begin to close, more work is needed to expand our understanding of the myriad ways in which math personalized learning software can be implemented to create strong blended learning environments that effectively differentiate the level and pace of mathematics instruction to meet the learning needs of each student.

The results of the current study provide insights into factors that might contribute to a "digital use divide" in Utah wherein some teachers are using math personalized learning software in ways that enhance students' mathematics learning through student-centered and data-informed teacher support while other teachers are using this technology in ways that can lead to student disengagement and educator disaffection.

peer learning, using data to inform re-grouping as appropriate, and encouraging students to use software-provided data to track their own learning progress.

Educators who participated in the current study were clear that there is no “one-size-fits-all” model for effective implementation of math personalized learning software, but that effective implementation *will* require substantial commitments from both teachers and LEA leadership. Specifically, effective implementation will require that educators have the flexibility, time, and resources to:

- receive timely school- and grade-level-specific training,
- access and use data to inform their teaching,
- receive “just in time” support from experts and/or from networks of fellow practitioners,
- experiment with new instructional approaches,
- develop strategies to support students individually or in small groups using the immediate feedback provide by software programs, and
- collaborate with colleagues and administrators.

The results of the current study provide insights into factors that might contribute to a “digital use divide” in Utah wherein some students are using technology in ways that enhance their mathematics learning through student-centered and data-informed teacher support while other students are using technology in ways that lead to student disengagement and that contribute to educator disaffection. Without thoughtful attention to the ways in which math personalized learning software is being implemented, LEAs may unwittingly contribute to this divide just as gaps in access to technology are beginning to close (U.S. Department of Education, 2017; Utah Education and Telehealth Network, 2020; Utah State Board of Education, 2020). In future work, the UEPC aims to empirically test the degree to which the promising practices identified here and in other research are associated with positive teacher attitudes about math personalized learning software, positive student attitudes about math personalized learning software, and/or improvements in students’ mathematics achievement.

Introduction

Background

The K-12 Math Personalized Learning Software Program is a cornerstone of recent education initiatives supported by Utah's STEM Action Center. The purpose of the program is to provide students in kindergarten through 12th grade access to math personalized learning software. School districts or charter schools apply to the STEM Action Center for grant funds to purchase licenses that provide students and educators access to approved math personalized learning software. The approved list of software programs is updated annually.[1]

Although several recent meta-analyses have linked the use of educational technology – including math personalized learning software – to positive mathematics learning and achievement outcomes (Cheung & Slavin, 2013; Li & Ma, 2010; Ma, Adesope, Nesbit, & Liu, 2014; Steenbergen-Hu & Cooper, 2013; but see Campuzano, Dynarksi, Agodini, & Rall, 2009, and Dynarski et al., 2007), researchers caution that educational technology does not inevitably or independently produce these outcomes. Instead, the impact of education technology appears to be moderated by myriad contextual factors including teachers' competence in using the technology. Supporting this proposition is evidence that educational technology is more likely to enhance learning when it is used by teachers who are trained to implement it effectively (Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020). Much more work is needed to understand how math personalized learning software is being implemented in classrooms and to identify the specific implementation practices that are most clearly associated with positive teacher and student perceptions of the software and with positive student mathematics attitudes and achievement for different learners in different contexts (Walkington & Bernacki, 2020; Zhang, Yang, & Carter, 2019).

The current study begins to fill this gap by working to identify and learn from educators who have demonstrated a pattern of success in using STEM Action Center-approved math personalized learning software to engage students and improve student outcomes in the state of Utah. This study builds upon prior work conducted by the Utah Education Policy Center (UEPC) as the external evaluator for the K-12 Math Personalized Learning Software Program. Prior work conducted by the UEPC has focused on examining teacher, administrator, and student perceptions of math personalized learning software (e.g., Auletto, Barton, Owens, & Rorrer, 2020; Onuma, Rorrer, Pecsok, & Weissinger, 2020) and associations between math personalized learning software usage levels and student achievement outcomes (e.g., Owens, Rorrer, Ni, Onuma, Pecsok, & Moore, 2020; Su, Rorrer, Owens, Pecsok, Moore, & Ni, 2020).

One important take-away from prior work is that evidence for a positive relationship between math personalized learning software use and student achievement is strongest among students who have higher levels of program use (i.e., among students whose monthly usage puts them in the top 25% of students in terms of usage; see Owens et al., 2020; Su et al., 2020). This finding is consistent with findings from a meta-analysis which indicates that relationships between educational technology use and student mathematics achievement are higher when program intensity and level of implementation are high – that is, when intended use is greater than 30 minutes per week and programs are implemented with high fidelity (Cheung & Slavin, 2013). At the same time, there is some evidence that positive associations between usage and achievement begin to drop off (or even become negative) at very high levels of use (e.g., of greater than 200 minutes per month) for some products (see Altermatt, Altermatt, Rorrer, & Moore, 2022). Based on these findings, learning from educators who have students with *both* high levels of program use and high levels of math achievement is the focus of the current work.

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[1] https://stem.utah.gov/educators/opportunities/k-12-math-personalized-learning-software-grant/

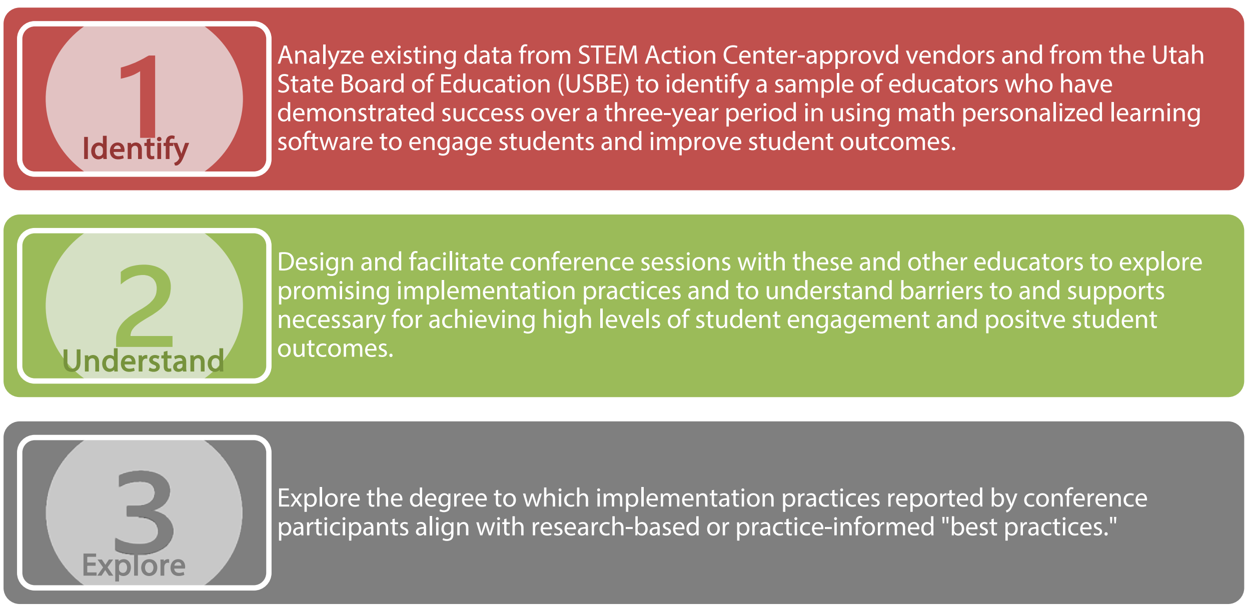
Overview of Research

For the 2021-2022 academic year, the UEPC contracted with the STEM Action Center to conduct a study designed to address two research questions:

1. What are the implementation practices of educators who have demonstrated a pattern of success over a three-year period in using personalized math software to engage students (as measured by student usage) and to achieve positive student outcomes (as measured by standardized math assessments)?
2. To what degree do these implementation practices align with research- or practice-informed best practices?

To answer these questions, the UEPC engaged in the activities outlined in Figure 1.

Figure 1. Overview of activities



Data Sources

The data used for this study came from three sources. First, using a secure platform, each vendor on the STEM Action Center-approved vendor list provided software usage data to the UEPC for three academic years (i.e., 2016-2017, 2017-2018, and 2018-2019). The current study utilized student usage data provided by the six vendors – ALEKS, DreamBox, i-Ready, Imagine Math, Mathspace, and ST Math – that were on the approved vendor list for the STEM Action Center as of January 2022. Information about each vendor, provided by vendors, is available here: https://stem.utah.gov/educators/opportunities/k-12-math-personalized-learning-software-grant/ .

Second, the UEPC utilized teacher and student demographic and achievement data that was made available via a Data Share Agreement with the Utah State Board of Education (USBE).[2] Data included 2017 and 2018 SAGE and 2019 RISE student growth percentile (SGP) scores and mathematics proficiency scores.[3] To ensure adequate sample sizes, analyses were limited to educators teaching students in 3rd grade through 8th grade in 2016-2017, 2017-2018, 2018-2019.[4] A dataset was created by matching student software usage data provided by vendors to USBE demographic, educational, and achievement data using matching algorithms.

Third, qualitative data were gathered from educators who attended the STEM Best Practices Conference hosted by the STEM Action Center. The conference was held in three locations in Utah (i.e., Ogden, Price, and St. George) in June 2022. Data-gathering sessions were facilitated by UEPC staff.

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[2] The Utah Education Policy Center has a Master Data Sharing Agreement with the Utah State Board of Education for use of education data for evaluation and research purposes. The UEPC adheres to terms of the Master Data Sharing Agreement, including terms of use, confidentiality and non-disclosure, data security, monitoring, and applicable laws. The UEPC also complies with University of Utah Institutional Review Board policies for educational research and evaluation. Though UEPC is housed at the University of Utah, only authorized UEPC staff may access the data, and data are not available throughout the University or to other parties. The views expressed in this report are those of UEPC staff and do not necessarily reflect the views or positions of the USBE or the University of Utah.

[3] RISE assessments replaced SAGE assessments in 2019. More recent achievement data were not available at the time that research activities related to this report began in January 2022. Specifically, RISE assessments were not administered during the 2019-2020 academic year because of the Covid-19 pandemic and RISE assessment scores were not released to the UEPC for the 2020-2021 academic year until March 2022. Only teachers who had at least 10 students using math personalized learning software were included in analyses to enhance the reliability of estimates of engagement and achievement.

[4] The majority of users of STEM Action Center-approved math personalized learning software programs are in elementary school (see Su et al., 2020). In addition, SAGE and RISE achievement tests are administered only to students in Grades 3 – 8.

Activity 1| Identify

Methods

The UEPC began its work by identifying educators who demonstrated success over a three-year period in using math personalized learning software to engage students (as measured by student usage, measured in mint) and to achieve positive student outcomes (as measured by standardized math assessments).[5] These "positive outliers" were identified using a three-step process outlined in Figure 2.

Figure 2. Steps for identifying educators demonstrating success in engaging students and improving student outcomes

Step 1.

- For each of the 2016-2017, 2017-2018, and 2018-2019 academic years, we identified educators of 3rd grade through 8th grade students who were teaching classes in which students were using one of six math personalized learning software programs on the STEM Action Center-approved vendor list.

Step 2

- For each educator, we calculated a metric of ***engagement*** (i.e., the mean number of minutes students in the classroom used the software each month) and a metric of ***achievement***. For educators in grades 4-8, we used mean student growth percentile (SGP) scores in math. For educators in grade 3, we used the percent of students who were proficient in math.

Step 3

- For each vendor, we identified educators who were in the top 25% of educators on ***both*** the **engagement** metric and the grade-appropriate **achievement** metric. Because both usage and achievement varied by vendor, cutoffs were different for each vendor.

Results

Following the steps outlined above, we identified 249 educators across vendors who demonstrated success over a three-year period in using personalized math software to engage students and to achieve positive student outcomes. Cutoffs for the engagement and achievement metrics for each vendor are

[5] For 4th – 8th graders, mean student growth percentile (SGP) scores in math were used as the measure of achievement. SGP is a continuous variable that indicates the level of student growth or improvement from the previous year relative to peers. SGP scores can range from 1 (lowest growth) to 99 (highest growth). For example, a SGP score of 52 indicates that the student showed more growth or greater improvement than 52% of other students who performed similarly the previous year. SGPs are often used as a measure of teacher effectiveness because they reflect how much a student has grown compared with peers with similar academic trajectories, they can be aggregated across students in a classroom to create a score for each teacher (here, mean SGP), and because they are easily interpretable. SGP scores are not available for 3rd grade students as SAGE and RISE assessments are administered for the first time in 3rd grade. For these students, % proficient was used as the achievement metric.

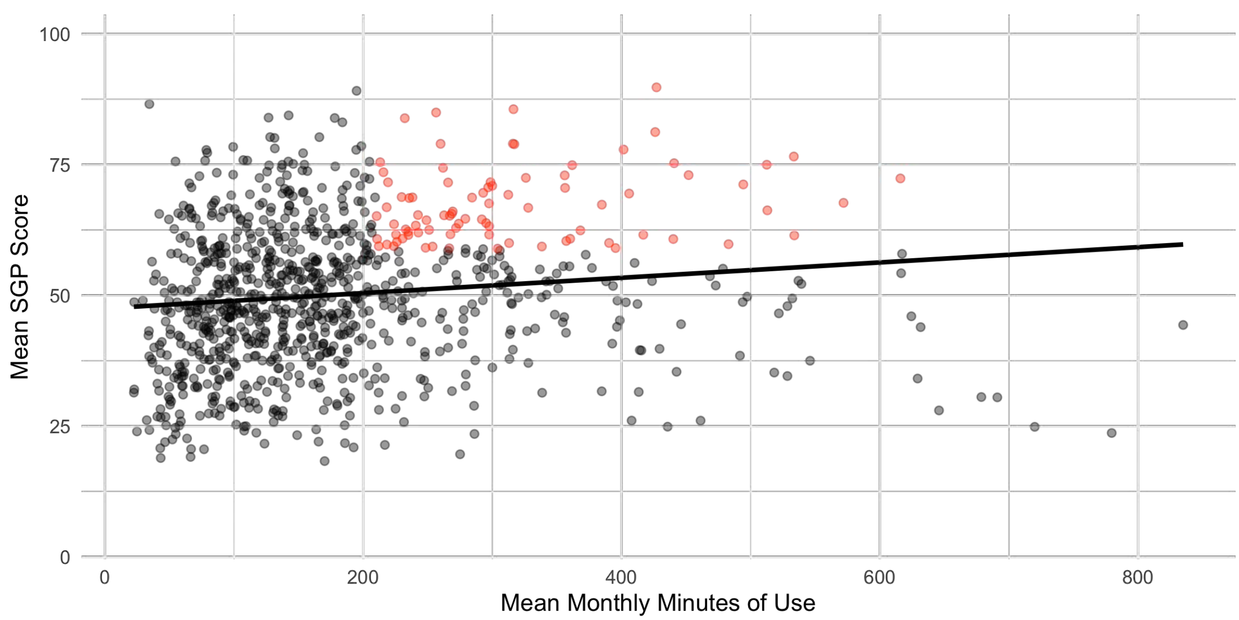
provided in Table 1. The number of educators who met or exceeded cutoffs on both metrics for each vendor are also provided.[6]

Table 1. Cutoffs for engagement and achievement metrics by vendor

Vendor	Engagement	Achievement		Number of educators
	Cutoffs for Mean Monthly (Weekly) Minutes of Use[7]	Cutoffs for Mean SGP Score (Grades 4 – 8)	Cutoffs for % Proficient (Grade 3)	
Aleks	>209.96 (>52.49)	>58.91	>67%	82
DreamBox	>137.42 (>34.36)	>71.09	>73%	3
i-Ready	>182.74 (>45.69)	>59.47	>68%	37
Imagine Math	>117.89 (>29.47)	>60.92	>67%	65
Mathspace	>101.84 (>25.46)	>65.05	>78%	6
ST Math	>184.06 (>46.02)	>59.99	>62%	56

For illustrative purposes, these same data are presented graphically in Figure 3 for educators using ALEKS in 4th – 8th grade classrooms. Note that educators identified as "positive outliers" are highlighted in red. Similar figures for each vendor and grade-level (i.e., Grade 4-8 and Grade 3) are presented in Appendix A.

Figure 3. Scatterplot of mean monthly minutes of use by mean SGP score for educators using ALEKS software in 4th – 8th grade classrooms.



[6] Educators who appeared more than once in the list of educators who were in the top 25% of educators on both the engagement and achievement metrics were included only once in the counts in Table 1. Educators could appear more than once if they used more the one software program during the three-year period covered in the current study.
[7] For ease of interpretation, monthly usage was converted to approximate weekly usage by dividing monthly usage metrics by 4.

Of the 249 educators identified in Table 1, 206 (83%) continued to work as educators in Utah during the 2020-2021 academic year. Demographic and educational information for these educators is provided in Table 2.

Table 2. Grade, district, and demographic information for selected teachers

Variable	*n* (percent)	Mean (Range)
Vendor		
Aleks	72 (35%)	--
DreamBox	2 (1%)	--
i-Ready	32 (16%)	--
Imagine Math	51 (25%	--
Mathspace	5 (2%)	--
ST Math	44 (22%)	--
Grade Level		
3rd grade	39 (19%)	--
4th grade	31 (16%)	--
5th grade	46 (22%)	--
6th grade	32 (16%)	--
Other (e.g., 7 -8th grade, administration)	58 (28%)	
School District (with ns > 5)		
Alpine	7 (3%)	--
Canyons	12 (6%)	--
Davis	45 (22%)	--
Granite	20 (10%)	--
Jordan	16 (8%)	--
Nebo	12 (6%)	--
Ogden	6 (3%)	--
Salt Lake	6 (3%)	--
Washington	16 (8%)	--
Weber	10 (5%)	--
Demographics		
% Female	183 (89%)	--
% White	191 (93%)	--
Age	--	47.72 years (26 – 72 years)
% holding master's degree	77 (37%)	--
# of years teaching	--	14.98 years (4 – 38 years)

Activity 2 | Understand

Educators who were identified as "positive outliers" were invited to participate in post-conference sessions at the STEM Best Practices Conference. These sessions were valuable for learning about promising implementation practices for math personalized learning software.

In Spring 2022, each of the 206 educators identified as a "positive outlier" in Activity 1 was invited to participate in one of three data-gathering events scheduled as a "post-conference" session at the STEM Best Practices Conference hosted by the STEM Action Center. The STEM Best Practices Conference was held at three locations across the state of Utah: Ogden, Price, and St. George in June 2022. Conference participants were encouraged to attend the conference closest to them. The post-conference sessions were designed and facilitated by the Bridgeworks Team at the Utah Education Policy Center (UEPC) to better understand the unique approaches of each educator in using math personalized learning software in their classrooms and to provide insights into any common elements or themes in educators' perceptions or experiences. Across the three sites, nine educators participated in a post-conference session for teachers who were identified as "positive outliers." The post-conference sessions were valuable for learning about promising implementation practices for math personalized learning software.

The UEPC also facilitated "regular" conference sessions at each of the three sites during the STEM Best Practices Conference. These sessions were open to all participants and were designed to gather additional data on how educators are using math personalized learning software for improving student outcomes, particularly as LEAs work to address pandemic-related learning loss. Across the three sites, three educators identified as "positive outliers" and 17 additional educators participated. These regular conference sessions were especially valuable for learning about barriers to and needed supports for effective implementation of math personalized learning software.

All conference attendees had the opportunity to participate in a regular conference session. These sessions were valuable for learning about barriers and needed supports for effective implementation of math personalized learning software.

Data from both post-conference and regular conference sessions were collected in two ways. First, educators were asked to respond to a series of question prompts using Padlet, a web platform that allows for real-time collaboration. Second, educators were asked to elaborate on their responses to these questions in dialogue with facilitators and with other participants. Both post-conference and regular conference sessions were audio-recorded and transcribed.

Findings from Post-Conference Sessions

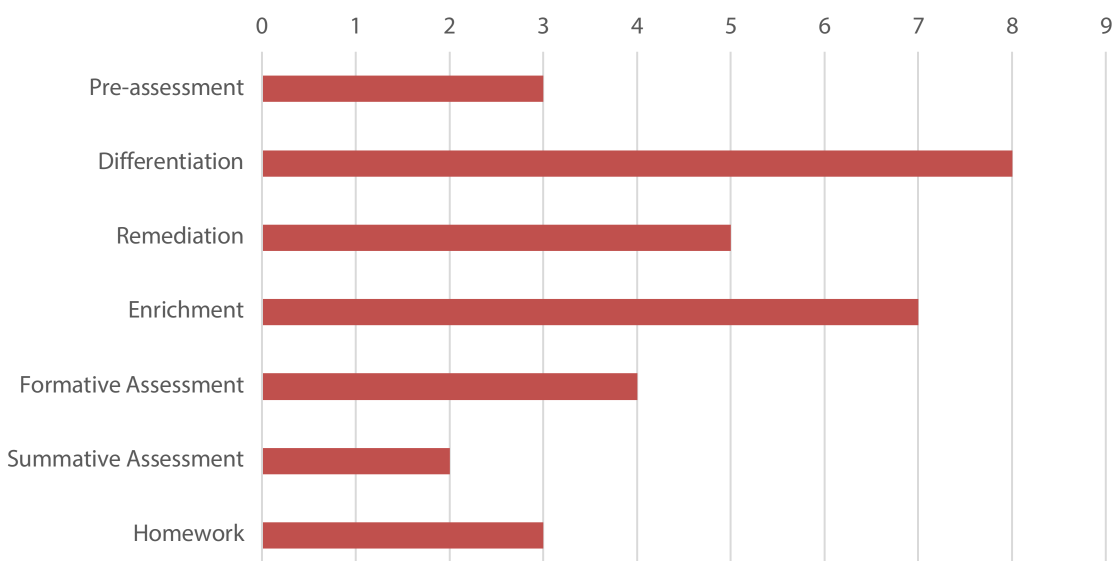
The nine educators who participated in the post-conference sessions represented five school districts and one charter school in Utah. A summary of the self-reported most recent teaching assignments of these educators and the software programs used by these educators during the most recent academic year (i.e., 2021-2022) is presented in Table 3. As shown, the majority of participating educators were elementary school teachers. Four of the six vendors on the STEM Action Center's approved vendor list were represented on the list of programs used by these educators during the most recent academic year. All six vendors were represented on the list of programs used by these educators in the past five years. Importantly, only five of the nine educators were currently using the same program that they were using when they emerged as a "positive outlier" (i.e., using data from the 2016-2017 through 2018-2019 academic years).

Table 3. Characteristics of post-conference participants

Variable	Count
Teaching Assignment in Academic Year 2021-2022	
4th grade teacher	2
5th grade teacher	4
6th grade teacher	1
6th, 7th, and 8th grade teacher	1
Other	1
Software Programs Used in Academic Year 2021-2022 (select all that apply)	
ALEKS	1
DreamBox	1
i-Ready	4
Imagine Math	4
Software Programs Used in Past 5 Years (select all that apply)	
ALEKS	3
DreamBox	1
i-Ready	4
Imagine Math	4
Mathspace	1
ST Math	1

Prior to the conference sessions, participants were asked to indicate the purposes for which they used math personalized learning software. As shown in Figure 4, educators were, as a group, most likely to indicate that they used software for differentiation and enrichment and least likely to report that they used software for summative assessment.

Figure 4. Number of educators identified as "positive outliers" who reported using math personalized learning software for each purpose



A facilitation guide for the post-conference session is provided in Appendix B. The four research questions that guided the facilitation of the post-conference sessions as well as the prompts associated with each of the four research questions are included in the guide. The findings presented here are organized by research question.

Research Question 1 | What pedagogical practices do educators who are identified as "positive outliers" view as most impactful when teaching mathematics?

In written remarks and in conversation, educators who were identified as "positive outliers" and who attended one of the three post-conference sessions highlighted myriad practices that they viewed as impactful in their teaching of mathematics. Importantly, while few educators explicitly mentioned the use of math personalized learning software as a "most impactful" practice, the three themes that emerged in response to this question (i.e., about teaching practices in general) re-emerged later (i.e., in questions about math personalized learning software in particular). For example, one theme that emerged in written remarks and in conversation about impactful teaching practices was that gathering, sharing, and acting on information (e.g., about areas where students might be confused about a particular math concept) was especially important. Later in the session, many of the educators identified as "positive outliers" noted that one of the value-added aspects of math personalized learning software was the ability to gather, share, and act on the immediate feedback the software provided.

Theme 1. Educators identified as "positive outliers" provided time for students to engage in effortful learning activities.

For educators identified as "positive outliers," effortful learning activities included

- providing opportunities to review key concepts daily (e.g., with "bellringer" activities assigned at the beginning of each class),
- asking students to grapple with new concepts on their own to enhance their mathematical reasoning and problem-solving skills,
- providing students time to practice new skills,
- providing time and encouragement for students to engage in math discourse with peers in dyads or small groups,
- providing answers to daily work to encourage students to check their work and to try alternative strategies to solve a problem if their first attempt yielded an incorrect answer, and
- being intentional about reviewing with students what was learned at the end of each class period.

Theme 2. Educators identified as "positive outliers" gathered "just-in-time" data to inform their teaching and to provide immediate feedback to their students.

Educators identified as "positive outliers" gathered data and provided feedback in multiple ways including the following.

- Several educators indicated that interacting with students in one-on-one tutoring or small group sessions was most impactful. One teacher noted that they used these sessions to "see directly what [students] are doing" while another indicated that they used these sessions to "understand all of my students' needs, and learning levels, and [learning] styles."
- One educator noted that using course management software (e.g., Schoology) to provide immediate feedback to students on course exams or assignments was most impactful. This educator noted that students benefited from the "instant feedback" to know "what they got

right or wrong" so that "we can discuss it right then." They noted that "immediate feedback holds a lot more weight than [feedback that is given] a week or two weeks later."

- Two educators indicated that asking students to participate in frequent, informal assessments was most impactful. One educator frequently and spontaneously called on students to answer a question about material that was being covered in class. This educator noted the importance of creating a classroom culture that felt both safe and where "constant accountability" was expected. Another educator indicated that frequently asking students to self-report on their level of understanding on a five-point scale allowed them to offer additional one-on-one or small-group assistance to students who were at a "three or less."

Theme 3. Educators identified as "positive outliers" actively worked to instill positive attitudes toward mathematics in their students.

Educators identified as "positive outliers" encouraged the development of positive math attitudes in myriad ways including by

- introducing new mathematics concepts with stories and real-world examples to which students could relate before asking students to complete problems from a textbook;
- teaching students to develop a growth mindset (i.e., to believe that anyone can succeed in math with effort);
- creating a classroom culture of "care and patience" where students have the courage to share even (initially) incorrect answers; and,
- "empowering students [to know that there are] multiple ways of solving a problem without guessing."

Importantly, each of these themes is strongly aligned with well-established "best practices" for teaching mathematics (NCTM, 2014; ULead Education, 2021).

Research Question 2 | How central is math personalized learning software to of educators identified as "positive outliers" and to the learning of their students?

Educators identified as "positive outliers" reported that they viewed math personalized learning software as a useful tool to gauge student understanding, provide instruction that was tailored to student needs, and allow students opportunities to practice key skills at a level that was appropriate for their current level of mastery. Several educators noted that they used the software daily. Although specific implementation practices varied across educators, all participating educators indicated that they found value in the software for informing their teaching and improving student learning.

In written remarks and in conversation, each of the educators who was identified as a "positive outlier" and who attended a post-conference session indicated that they viewed math personalized learning software as a useful tool to guide their teaching and to support student learning. Importantly, there was considerable variability across teachers in when and for what purposes they used personalized math software. Some educators reported using the software daily, while others reported using the software less consistently (e.g., only "after students are finished with their regular work and have proven that they are competent"). Likewise, the degree to which the software was used at the start of class or following whole-class instruction and for remediation, differentiation, enrichment, or assessment purposes varied across educators, with examples of all four types of approaches emerging in the data – sometimes alone and oftentimes in combination. For example, several educators noted that they used the software primarily *after* they had introduced a math lesson to the entire class as a way to reinforce the lesson, to give students opportunities for practice, and/or to differentiate instruction. In these cases, educators frequently mentioned the value of immediate feedback to both teachers and students.

> "I use it every day. I usually teach a lesson and then have an assignment in ALEKS."
>
> "I assign lessons that align with the lessons for the day, so students are receiving feedback instantly. They can check their understanding instantly so if they don't understand something they can come back for help immediately."
>
> "I use IXL math for students to practice the concepts and get instant feedback. I assign a topic and I have them practice and I can see their scores in real time. It also shows them how their answer was wrong and how to get the correct answer."
>
> "[I use the software to] support in-class activities. Students have a goal of how many DreamBox lessons to complete each week. [This] gives [students] extra practice in different ways. Students are given time daily to work on it."

Another educator noted that they used the software primarily at the *beginning* of class. This educator reported using the software simultaneously for assessment, differentiation, enrichment, and remediation; that is, to gauge the understanding of each student and to provide either challenging problems or extra support as needed.

> "I require [the use of software] as bell work every day. It gives me time to work one on one with students each day on their level. I can push high-[achieving] students or I can reteach strugglers."

Notably, all of the participating educators indicated that they found value in the software for informing their teaching and for improving student learning and engagement. In describing the value of the software, several educators focused on software reporting tools, noting that the software provided rich data that could be used to adapt instruction or provide remediation. For example:

> "[The] reports give good data."
>
> "[You can] use the data to adjust your lesson."
>
> "I really like the reports, because it would say, 'Hey, this kid has been trying this for a while, and they're not getting it.' So, that would give me the opportunity to go and check that out."

Other educators focused on the value of software in allowing students to practice math skills at a pace that was appropriate for their skill level. For example:

> "Students just get a lot more repetition. A lot more 'here are the steps.'"
>
> "Once [students] have mastered a standard, they can just move on to the next standard. That way, they're not …. waiting for the whole class to pass something. They just move when they're ready to move. Without the digital piece, I think I'd having a really difficult time making that work."
>
> "Students love the choice and ability to move at their own pace."

Several educators made clear connections between student software use and achievement, noting that the immediate feedback and repetition allowed students to make achievement gains quickly. For example:

> "Our test scores were really, really good this year based on [Edgenuity, which is part of Imagine Learning] …. A lot of my kids moved into seventh grade math. Some finished seventh grade math. I teach sixth."

> "I definitely have seen them grow … [Some] kiddos went from not being proficient at all to being proficient [on RISE] because they saw the same concepts over and over until they were able to take that practice and convert it to a memory of [how] to do the problem …. [The software] doesn't let them move on until they pass it. So, they have to practice it till they understand it …. In the classroom, we can't stay on a topic until all of the kids get it."

> "I like it because, for some of them, it does motivate them … to see their progress … It's also like a mini-competition with their peers, too. 'How far are you? What level are you on?' And, we obviously have seen the more topics you do, the better they do on their state testing …. We've plotted them out. Like their raw scores on the state testing and how many topics they pass. It's a pretty good correlation with that."

Another educator noted that software use supported achievement gains for struggling students, but that the value wasn't immediate or inevitable and required patience.

> "One thing people ask is 'What do you do that makes your kids' growth scores better?' I don't think I do anything different other than [help] my kids feel good and confident about themselves …. With my low kids … if they don't pass a lesson for a couple weeks, I don't pound them. They're trying. They're doing their thing …. [But] when we start heading towards RISE testing stuff, my lower kids start passing three, four, five, eight lessons a week in Imagine Math toward the end … It's my low ones that the software, I think, builds confidence [for] and that's where they find the true value …. They'll go 'I passed seven lessons this week' and everyone's happy for them. They feel good and they're like, 'I can do math.'"

Moreover, several educators were clear that they did not believe that student success was tied to a particular software program as evidenced by their experience that student achievement scores remained high even as software programs changed from year to year. Several educators also indicated that the culture in which software programs are used is critical. As one educator noted:

> "[What is important is] your class culture and your expectations …. There is no 'I can't' [in my classroom] … 'It's okay to be wrong, but let's learn from it.'"

Research Question 3 | What specific approaches have worked well for these educators to effectively integrate math personalized learning software into their teaching?

In written remarks and in conversation, educators who were identified as "positive outliers" and who attended a post-conference session offered several "promising practices" for effectively integrating math personalized learning software into their teaching. In future work, the UEPC aims to empirically test the degree to which these and other promising practices are associated with positive teacher attitudes about math personalized learning software, positive student attitudes about math personalized learning software, and/or improvements in students' mathematics achievement.

Promising Practice 1. Educators should use math software as a supplement to and support for strong mathematics teaching not as a replacement.

In *Learning First, Technology Second*, Liz Kolb (2017) notes that "Learning with technology doesn't happen because a specific tool 'revolutionizes' education; it happens when proven teaching strategies intersect with proven technology tools." This sentiment was reflected in the comments of several educators identified as "positive outliers." For example:

> "The mistake some schools and teachers make is they just let the computer program do its thing, and they don't intervene. You still have to be a teacher. You can't just assume that they're going to learn digitally, and kick back and let that happen. You have to track it, and you have to meet with them, and you have to intervene if they're confused by something."

> "I think that if you just use [the software] as a standalone, and you're like, 'Okay, go do your program, and I'm never going to talk to you about what you're learning, or what the computer's having you do,' it's just not terribly effective because the kids are just out there on their own …. [Software has to be used in] a blended learning environment where you're using it as a tool, not as a main source of [teaching]."

> "Math software is a supplement not a teacher. The teaching needs to come from the teacher and the software should be used to help reinforce and practice what is being taught."

Promising Practice 2. Educators should have clear goals for using math personalized learning software, and they should share these goals with their students.

Several educators noted the importance of creating a classroom culture in which students knew what was expected of them in using the software. For one educator, this "promising practice" was reflected in their decision to set clear weekly goals for students combined with clear incentives for achieving those goals:

> "I use Imagine Math daily. Students need to pass/complete three lessons a week. They are given five days of 30 minutes each day. Once they pass three lessons, they are rewarded with different … learning activities. I also have a prize for the three students who have passed the most lessons. I also have a grand prize for the top student."

For another educator, this "promising practice" was reflected in using software assessment data to identify areas of weakness before state achievement testing and working very closely with students to utilize math personalized learning software to improve associated skills.

> "[Students] need to know what it is you're doing. When I would come to the end-of-the-year testing with ALEKS …. I would pull up that report, and I would look at all of the standards, and I would pick the bottom six …. And I would say, "for my class, here are the six." And that's what we hit the last week and a half …. they knew I wasn't just generally doing everything …. I was super clear on what we were going to hit right at the end."

Several educators indicated the importance of revisiting their software goals throughout the school year. Responses indicated that reviewing and problem-solving may be especially important when goals are time-related. Several educators expressed challenges associated with time-related goals, especially for software programs with lengthier lessons. For example:

> "Part of the problem is that … you're giving them 20 minutes. [The program is] going to cut them off in the middle of a lesson …. They have to come back the next day and try to remember what they were in the middle of rather than being able to think cohesively and finish an entire section."

> "We didn't do time. I don't like time because the kids have found they can just sit on the screen and do nothing …. Time doesn't count unless you're doing something. [Instead] we gave an incentive for every topic they finish or every lesson they finish …. And the kids can move through it even if they are on the lower levels because it's on their level …. And our higher kids can finish and they can finish quick. And then we incentivize their extra. So those kids who are faster finishers and want to get through and learn more are really encouraged and excited to … move faster and faster."

Promising Practice 3. Educators should use data from math personalized learning software in real time to inform their teaching.

There was broad consensus across educators that access to real-time data is one of the most important benefits of using math personalized learning software. Educators identified as "positive outliers" noted, however, that many educators don't use or don't know how to use the data. For example:

> "[Educators need to] know how to find the data you need and do this early in the year."
>
> "You need to know the program. You need to see all the information that it can give you. Don't just say, 'Ok, kids, we have to do this. The school's asked us to do it.' No, look at the report … 'Oh, they're struggling with this. Oh, they're spending 40 minutes on one lesson and still not passing.' Understand the information it gives you. And then I think you need to set a regular time to use it."
>
> "I can see in real-time who is understanding the concept [and] who is not understanding the concepts. [I can also see] if they are learning from their mistakes because it shows them the correct way of answering the question. I can evaluate that. Also, I give rewards for students who do more things than they're required to do."

Several educators noted that, in reviewing the data, it is especially important to identify individual students or sub-groups of students who may be struggling with the software "so they are not frustrated" and have "the tools they need to be successful." While some educators indicated that lower-performing students were most likely to struggle, others suggested that higher-achieving students had the most difficulty in engaging with the software, especially when the software challenges them. For example:

> "I will say the high achievers tend to shut down quicker than my struggling students, and I think it's because the struggling students have had to struggle. They had to learn to struggle. I'm in sixth grade. They've had years of struggle at that point, where the high achievers do tend to be like, 'Well, I don't get it, so I'm just going to quit. It's too hard' …. And when I really push them, they do get... They have a really low threshold for frustration."

Promising Practice 4. Educators should be willing to experiment with how to use math personalized learning software in ways that take advantage of the strengths of educational technology and that build upon their own pedagogical skills.

Several educators who were identified as "positive outliers" noted that it took them several years to develop effective strategies for integrating math personalized learning software into their teaching. One educator noted that they took advantage of opportunities to learn from others, including by collaborating with a school colleague, attending training offered by vendors, posting to community boards offered by vendors, and visiting other classrooms to improve their practice.

Other educators noted that they worked to remain open to new ideas about how to use the technology. For example:

> "The kids like the fact that they could choose what to do. There wasn't like a specific, 'Okay, everybody's going to be doing fractions.' And at first I was hesitant, but then [I saw the benefit of offering students an opportunity] to touch the same concept again and again ….. It gives them their own self-selected type of spiral review. And that was really good."

> "I think a lot [about] how to keep it engaging; making it into a game. I found ways to make i-Ready into a game to make them be invested in it. That's something the program is not going to offer. It's the teacher knowing how to do that."

> "As I talked to my team, I found out they have goals [for using software]. I said, 'What are your goals?' Then I started setting goals for my kids. And they did better. And then you celebrate the success."

Promising Practice 5. Educators should be prepared to recognize the challenges and limitations of software.

All of the educators identified as "positive outliers" indicated that they had used more than one software program, including some programs not currently supported by the STEM Action Center. Although there was no consensus among educators on which software programs were most effective, there was consensus that each program has limitations. Among the concerns raised by educators were concerns that some software programs suffered from lessons that a) were too long, b) could not be easily linked to lessons covered in class, or 3) led to frustration among students who struggled with the interface or with the content. Educators also expressed some frustration with their inability to choose the software they would be asked to use in their classrooms, especially given individual differences in teacher pedagogical practices and student approaches to learning. For example:

> "We didn't have a say in what program we used."

> "Not everyone learns from the same kind of software. [Educators need to] use the right software for the right student."

Notably, several educators indicated that it was beneficial for students to have exposure to multiple programs to maintain engagement.

> "[This is the] third year of these kids using it. They hate it. They don't like it anymore. They've learned how to manipulate it."

> "It's too much of the same, year after year."

Research Question 4| How do educators who have been identified as "positive outliers" envision that math learning software might be used in transformative ways?

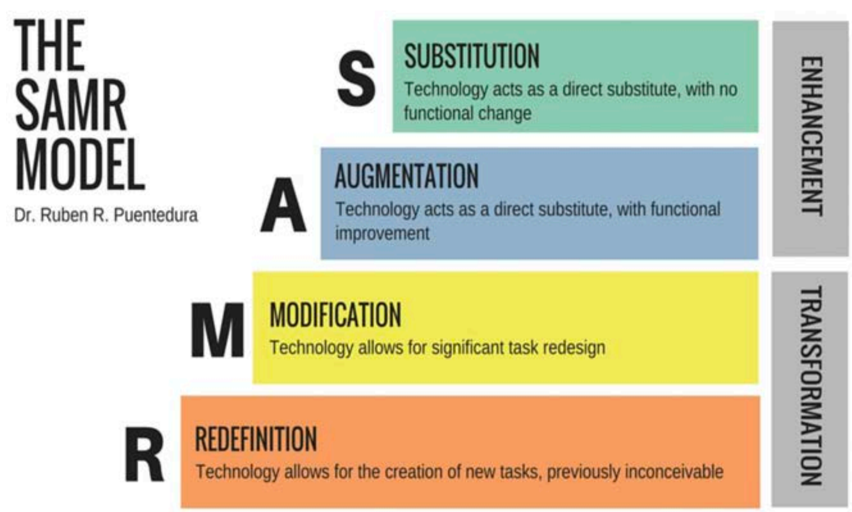
Educators identified as "positive outliers" noted that the ability to use math personalized learning software to collaborate with or tutor peers and to share their learning with family members is a feature that is currently missing in current software programs but that is potentially transformative.

Several educators identified as "positive outliers" struggled to provide examples of how they were currently using software to transform instruction as defined in the SAMR model (see Figure 5 and Appendix B). For example, two educators debated whether their use of math personalized learning software was at the level of "substitution" or at the level of "augmentation," perhaps with some elements of "modification". For example:

> "I think software is just a tool. There are innovative ways to use the tool … but, ultimately, it really is just a substitution level [tool]."

> "I think it's augmented, because it functionally gives [students] feedback versus them taking the paper home and doing the whole page wrong …. And, then, when it gives them those steps of what to do, I think it's more than just substituting as a paper. The 'task redesign,' I think, is when [students] use ST Math …. to really think outside the box of how to make this work. And, it provides feedback …'No, that didn't work. Try something else.'"

Figure 5. SAMR Model



However, there *was* interest in thinking about how the software *could* be used in transformative ways. As one educator noted:

> "It is possible to use software in transformative ways, but we need more time with the programs we have and time to sit down with others to work on it."

In addition, several educators expressed interest in or provided examples of how they were currently using math personalized learning software *in combination with* other pedagogical approaches or other types of educational technology to create new, positive learning experiences for students. For example, one educator noted that, when students completed software lessons – including lessons that were at a higher grade level – they gave students an opportunity to teach that concept to the class. Specifically,

> "I've had students teach this year up to seventh-grade math concepts in class …. That's a whole other level of math understanding and having them feel great about themselves … And, I'd make a video of them teaching that concept to the class and send to their parents. And so, when the kids

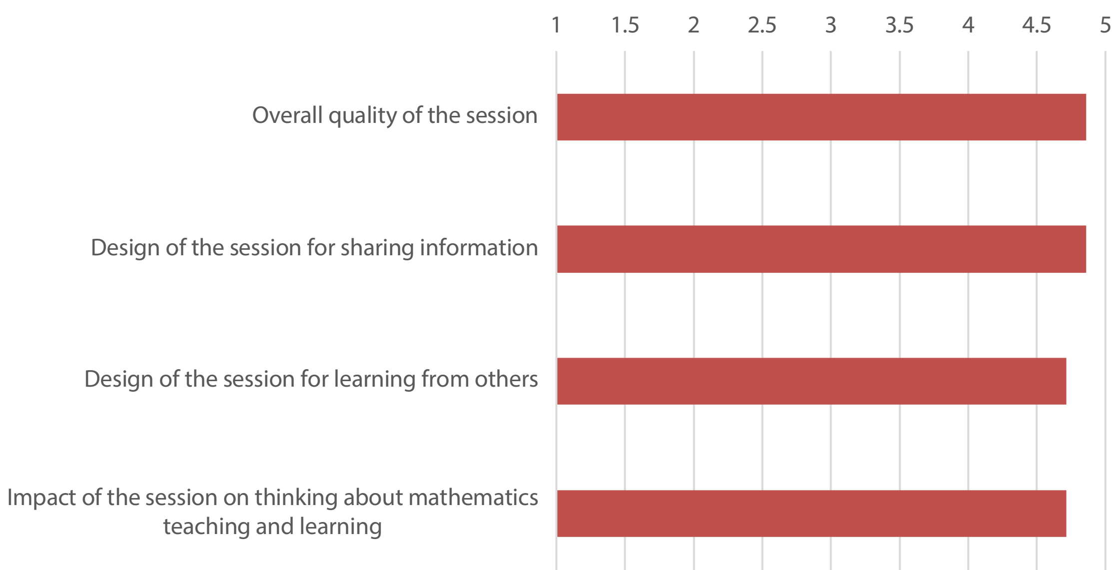
get home, the parents are like, ‘I can't believe you taught this seventh-grade concept. This is amazing.’ So, then the kid is even more motivated to do even more. I'm all about pushing how they feel about themselves in math.”

There was some consensus among educators that the ability to use math personalized learning software to collaborate with or tutor peers and to share their learning with family members is a feature that is currently missing in current software programs but that is potentially transformative.

End-of-Event Feedback Survey

At the conclusion of each post-conference session, participants were asked to complete an end-of-event survey. Respondents were asked to rate the overall quality of the session, the design of the session for sharing information, the design of the session for learning from others, and the impact of the session on their thinking about mathematics teaching and learning on a scale ranging from 1 (poor) to 5 (excellent). As showing in Figure 6, ratings were overwhelmingly positive with mean ratings between 4 (“very good”) and 5 (“excellent”) for all four items.

Figure 6. Ratings of post-conference participants



Participants responses to an open-ended question asking them to explain their ratings indicate that participants were especially appreciative of being able to share their experiences and learn from professional colleagues.

> *“It was great to be able to share and learn from others’ experience.”*
>
> *“This was a great opportunity to share my thoughts, hear others, and learn about other math software programs.”*
>
> *“I appreciate the opportunity to share!”*
>
> *“It was very enlightening and thoughtful.”*

Participants made similar comments when asked to indicate what aspects of the session were most valuable to them.

> *"Hearing from other teachers and what works for them."*
>
> *"This was so great to participate in! I loved sharing the way I use technology and hear others' thoughts and ideas. Thanks for the opportunity!"*
>
> *"Learning about different math software programs."*
>
> *"I appreciate being able to share ideas."*
>
> *"I was able to think more deeply about how I was using the software and how students can show what they learn."*

Findings from Regular Conference Sessions

In addition to the three post-conference sessions, the UEPC developed and facilitated three regular conference sessions focused on understanding how mathematics software might be used to support pandemic recovery efforts. The sessions were open to all conference registrants. Across the three sites, 20 educators attended these sessions including three educators identified as "positive outliers."

The session was advertised as follows:

Best Practices and Strategies for Using Mathematics Personalized Learning Software to Support Pandemic Recovery Efforts
Although mathematics personalized learning software has the potential to play an important role in helping students learn and recover from pandemic-related learning loss, more work is needed to understand how this software is effectively being implemented in Utah's classrooms and to identify the specific practices and conditions under which software use may yield improved student outcomes. The purpose of this session is to learn from teachers: How are you using mathematics software in your classroom? What are the benefits of using mathematics software and what are the challenges? What kinds of supports are needed to maximize the value of mathematics software as a COVID recovery intervention?

The findings presented here are organized into four sections. In the first section, we summarize the implementation practices of participants. In the second section, we highlight participating educators' perceptions of the benefits of math software. In the third and fourth sections, we describe participating educators' perceptions of barriers to and supports needed for effective implementation. Throughout, we note similarities and differences between themes that emerged in the post-conference and regular conference sessions.

Implementation Practices

There was considerable variability in *how* participating educators used math personalized learning software. As a group, educators who participated in the regular conference session reported using one or more software programs in class or for homework for a variety of purposes including remediation, differentiation, enrichment, and assessment. Several educators incentivized software engagement and were intentional about communicating clearly with parents and students about the goals of software.

Educators who participated in the regular conference sessions reported using a variety of different types of math software in their classrooms. Some of the programs were on STEM Action Center's approved vendor list including ALEX, i-Ready, Mathspace, and ST Math. In addition, educators reported using a number of other programs including DeltaMath, Formative, and MyMathLab that are not currently on the approved vendor list. One educator was especially enthusiastic about Formative as it has the capability of allowing teachers to add their own content rather than relying solely on the content provided by software developers.[8]

As in the post-conference sessions, there was considerable variability in *how* participating educators used the software. As a group, educators who participated in the regular conference session reported using one or more software programs in class or for homework for a variety of purposes including remediation, differentiation, enrichment, or assessment, sometimes in combination. For example:

> "We are currently using i-Ready for remediation, but I have also used ST Math."
>
> "[We use software] to offer additional challenges for our accelerated students."
>
> "We use [one] program where kids just go at their own pace …. and so they can go as far as they want, but it's more independent …. A lot of my accelerated students love it and they push themselves."
>
> "We use [software] for assessment of student comprehension."
>
> "We use Formative for giving the students immediate feedback on their homework assignments."
>
> "We use ALEKS … for a lot of things: to determine where [students] are at, to help those struggling, [or] to extend students' learning if they're past … the grade level that they're in."

Also similar to the post-conference sessions, several participants in the regular conference session noted that they regularly incentivized students' engagement with the program and had clear goals for program use that they communicated with students and with parents.

> "It was all online, so I could keep track of which lessons they were on, and where their status was, and so I could see what each student was doing each day, and I'd offer awards. If they were on the current lesson each morning, I'd pass out [rewards]. 'Good job.' I'd say, 'Okay, this is everybody who's on track. If you're not on track, you have today, let's get back to work, and get back on track.' I try to do some positive reinforcement."
>
> "At the beginning of the year, when the parents came, I explained it all, and then I had a weekly newsletter, where 'here's a link, this is information, these are the lessons they're supposed to do this week.' So, I tried to really communicate very clearly. If you have any questions, we had a homework lab, so students could stay after … and get support doing that."

[8] According to EdSurge (edsurge.com), Formative is s a web-based tool that allows teachers to create assignments, deliver them to students, receive results, and provide individualized feedback in real-time. Teachers can use the platform to create new assignments for their students from scratch, or they can upload pre-existing documents and transform them into paperless assignments."

Perceived Benefits of Mathematics Software Use

Similar to educators who were identified as "positive outliers," there was broad consensus among educators who participated in the regular conference session that math personalized learning software is valuable insofar as it allows students to received immediate feedback, provides differentiated instruction, and allows for consistent, self-paced practice that can result in achievement gains. Several new themes emerged in the regular conference session, however, including that the software may be more engaging than regular instruction and can be used to mitigate cheating and identify and intervene with disengaged students.

Educators who participated in the regular conference session reported that math personalized learning software has a variety of benefits. Some of the benefits mentioned by these educators matched those reported by educators in the post-conference session. For example, these educators noted that math personalized learning software allowed students to receive immediate feedback, provided differentiated and alternative instruction to students, and allowed for consistent, self-paced practice that resulted in achievement gains. For example:

> "[One] thing I like is the immediate feedback. Kids aren't waiting for a teacher to correct their work. So, it's immediate feedback."
>
> "I can give them a diagnostic, and know exactly where those gaps are, standard by standard. Which would be incredibly hard to do without some kind of software doing that."
>
> "[The software] allows for individualized instruction which is very challenging for a teacher to manage on their own."
>
> "When kids get on there, we can see their scores, and what they're doing, and it tells me directly what I need to reteach, or what some of the classes aren't getting [so I can] work with them in small groups, and that other kids maybe need to move on and have some challenge ….. It helps me kind of provide differentiation in my classroom."
>
> "One of the benefits, too, is having someone else teach it in a way that maybe you didn't think of, and maybe that's the way that that particular child gets it, because all of a sudden, 'Oh, this makes sense now.'"
>
> "I think another benefit … is that kids can go at their pace. And, so, if students want to go through a lesson and move on to the next, they can. If they need to take more time, they can do that."
>
> "We have software that we use that correlates with each lesson, and so it provides students with an opportunity to practice what we just taught that day. Students who use it, they seem to stay up with our pace, and the students who don't use it, or who are not consistent, often are strugglers. I mean, there are students who struggle even with it, but we see this pattern of the students who use on a consistent basis, this practice, this support, seem to excel better than those who don't."

Novel perceived benefits also emerged in the regular conference sessions. One theme that emerged among educators participating in these sessions is that math personalized learning software could be especially engaging which increased persistence. For example:

> "[The software adds] an element of engagement for students (e.g., animations, badges, leveling-up) that makes the lesson more exciting than a traditional lecture-type lesson"

> "Kids are into technology, so incorporating it into math keeps them engaged."

> "[The software offers instruction that is] worded differently or it has maybe an extra step where it forces [students] to go just a little bit deeper in their thinking. So … it's helping them to persevere through the problem solving a little bit."

Individual educators in these sessions also suggested a number of additional perceived benefits including that the software mitigates cheating and alerts teachers when students have disengaged. Importantly, the tone of these comments was markedly different from those of post-conference participants who were more likely to describe looking for opportunities to create classroom environments where students felt "cared for" and "empowered." For example:

> "We always had problem with kids not doing their work and they'd come in and just give somebody else a worksheet and they'd copy it down …. [The software] gives them the same questions but with different numbers or things like that. So that's one thing we really like too. Again, not that they can't cheat but just it has made it so that it's not as easy to hand a kid a worksheet."

> "[The software] tell us if [the students' work] is late right away. That's another thing that I use. Like, 'well, yeah, you did this, but we took the test and you did it after the test and that's all documented' …. So, when parents come in … we have that proof, too, of when it was submitted or when it was done or 'yeah, your kid did work on this problem for an hour, but during this time he did nothing.' So, for people who use the data, it's very beneficial … but, I think it just depends on how much time you're going to put into the data."

> "If the kid sits too long on one screen, it actually takes a screenshot of their screen and sends it to the teacher in a report. And we kept getting reports of the student just logging in and sitting there. So, it would take a picture and say your student is stuck here. So we were able to bust the kids who were doing nothing."

Perceived Barriers to Effective Implementation

One of the key goals of hosting the regular conference sessions was to gather educators' perspectives on barriers to engaging students with math personalized learning software and to realizing associated gains in student learning. Across the three sessions, educators shared myriad barriers. In this section, we provide a brief description of each barrier followed by representative quotes.

Perceived Barrier 1. Educators can find it difficult to effectively use data provided by math personalized learning software to inform their instruction.

Several educators noted that teachers lack the time or ability to effectively use data provided by personalized math software programs.

> "At an elementary level, we don't have time. I mean, we have math, but, geez, the teachers are doing so many other things that the software is a nice piece to help support what they're doing in the classroom, but they're not spending a lot of time digging into the data or even monitoring the data. It's more of a practice or an enhancement or kind of a remediation level."

"[The software programs] kind of tend to highlight maybe what we already knew was there: that you have this wide range within any class of students who are just doing great and moving through the curriculum well, and those that are stuck …. [Teachers] don't really know what to do with that information once they receive it."

Perceived Barrier 2. The training available to teachers on how to effectively implement math personalized learning software can be inadequate or ill-timed.

Several educators noted that the training made available to teachers is either inadequate or ill-timed. For example:

"I feel like there were so many trainings. The teachers' complaint was they just got talked at versus time to look at the data, time to figure it out, and time to compare it to, like, where are your kids in comparison to the Acadience tests and your grade level content … So, it's more like the integration of [the software] where [teachers] might not be trained on."

"We were provided a little bit of training, but a lot of it was, like, after the fact. We'd already gotten into the program and we're, like, 'oh, well you can do this and this and this.'"

Perceived Barrier 3. Both students and educators can find math personalized learning software difficult to use or not sufficiently engaging.

Several educators noted that the software can be difficult to use for both students and educators or can be insufficiently engaging for students. For some educators, these difficulties are serious enough for them to question the value of the software. For example:

"[We need] more direction from our district [on] …. how do you use this? …. I know some of our teachers put the kids on [it but] there's really no direction for the kids on how to use it. Some of them play around, and I'm not sure if the data is all that accurate because the kids aren't using it accurately. So, there are a lot of questions we still have about [the software]."

"It's often the kids who don't have the direction from either home or the self-motivation that need [the software] the most, [but] don't use it correctly."

"They feel sometimes like they're always on it …. Instead of it being more of an excitement, it becomes more of a hum drum thing. So, it is trying to encourage them to keep doing what we're doing."

"Some of the [lessons] are hard …. There is a third grade one …. and I sat there with the student and … I had no idea how to do it …. You had to divide the shape … evenly into so many pieces … and, for the life of me, I could not figure out how you could divide that into equal pieces. I finally walked away. I'm like, 'Good luck.' … Sometime there is way more struggle than productivity for the kids … and some of them don't have that grit. And, so, they'll back out of that activity and find one they can do."

Perceived Barrier 4. Some students may not use math personalized learning software with fidelity.

Several educators noted that some students routinely cheat or rush through lessons when using the software program, making it ineffective for promoting learning. For example:

> "A lot of [students] are, like, 'oh, well, if you don't understand it, you can just click this and then click this and then it'll give you the answer" ….. So they've learned kind of how to cheat."

> "Kids will ask their neighbor how to do some things and we've been pretty strict about 'you don't talk to your neighbor and have them teach you' because then the computer assumes you know that, and then it bumps you up. We had a couple kids who we could tell were getting help at home because they were in concepts they were nowhere near ready to actually manage."

> "They're so smart that they'll work the system for their benefit, and they're not necessarily learning the material that you're wanting them to learn. So, when it comes time for those knowledge checks, they have no idea what to do because throughout the lesson, they've just kind of been working through other things to get through the lesson."

> "They don't slow down and do their best work. They're just trying to get to 'what do we get to do when we're done?' …. The attention span … is short for some of them, where they can't really take the time that they need to do it."

Perceived Supports Needed for Effective Implementation

Educators indicated that additional training and improved mechanisms for accessing, sharing, and comparing data is needed for educators to use math personalized learning software more effectively.

To overcome these barriers, educators suggested that they would benefit from additional training. Educators noted that training should

- be interactive,
- grade-level specific,
- focused on how to extract data to guide instruction, and
- focused on communicating the purpose of software use to teachers and on guiding teachers in communicating the purpose to students.

Several educators noted that the effectiveness of software would be improved if more teachers understood the importance of being present and engaged with students to provide "just-in-time" instruction and encouragement based on data. For example:

> "[The software] does give some instruction … and then it will take them through and review. So, it can be done … as a center … or with the computer lab manager … without a teacher managing it. But sometimes having that teacher there helps kids to stay more on task, so they're not redoing all of the [problems] that are easier for them and avoiding the ones that aren't … I think it can happen that the teachers are less involved and intentional about looking at it because they figure, well, the program is doing it … To make it more successful for everyone, you need to make sure that you're looking at that data … so that you know how to change and adjust your instruction within the classroom."

Finally, educators noted that they would benefit from the ability to more easily access, share, and compare data with administrators or with collaborators in other schools. For example:

> "One of the things that we found was that the administrative …. data was different than what the teachers were getting. So, we had access to some reports that they didn't that they really needed or could have used. [It would be helpful to] make sure that they have the ability to pull the same kind of reports and information that we have."

> "When we're collaborating with the other middle school, we can't see the reports and be like, 'Oh, hey, you did really good in this area. And we didn't. And what did you do?' We can't, we can't compare it very easily. So then would be sort of nice have access to that."

Activity 3 | Explore

To What Degree are Reported Implementation Practices Aligned with Research-Based and Practice-Informed "Best Practices"?

There is growing consensus that, to be effective, math personalized learning software needs to be integrated with high-quality instruction in ways that create strong "blended learning" environments. "Blended learning" has been defined as "a personalized learning approach that combines online and face-to-face instruction to differentiate the content, pace, and difficulty of instruction for each student" (REL Mid-Atlantic, 2017). Although there is some evidence that blended learning interventions can improve student outcomes (Brodersen & Melluso, 2017), a recent review of the extant literature indicates that "research has yet to definitively identify the strategies for implementing blended learning that increase the positive effects on students" (REL Mid-Atlantic, 2017).

Importantly, some promising practices have emerged in a series of studies that have examined the instructional practices of educators in schools that received Next Generation Learning Challenges (NGLC) grant funding. Each of the participating schools was committed to implementing school-wide "personalized learning" (PL) opportunities for students (Pane, Steiner, Baird, & Hamilton, 2015; Pane, Steiner, Baird, Hamilton, & Paine, 2017). Although the grant program did not require it, all of the schools practiced technology-enabled personalized learning through, for example, the use of math personalized learning software (REL Mid-Atlantic, 2017).

Several of the promising practices that emerged in the NGLC schools also emerged in the current study. That is, compared to a group of comparison educators, educators in schools that committed to school-wide approaches to personalized learning were

- *more* likely to use data to personalize their teaching,
- *more* likely to provide one-on-one, tailored support for students based on data,
- *more* likely to allow students to work at different paces and on different content, and
- *more* likely to require that students practice material until they demonstrate competency.

In addition, two additional promising practices emerged in the study of NGLC schools that emerged less clearly in conversations with educators who participated in the current study. Specifically, compared to a group of comparison educators, educators in NGLC schools were

- *more* likely to share data with students and encourage students to use data to track their own learning progress, and
- *more* likely to use student grouping strategies based on data.

Preliminary analyses of data from five of the most "successful" NGLC schools (i.e., schools with both strong PL implementation and strong achievement outcomes) indicated that educators at these schools were especially likely to engage in three "promising practices" in tandem. Specifically, educators in these schools 1) used data to group students, with frequent adjustments based on data, 2) provided data to and discussed data with students, and 3) created learning spaces that were conducive to personalized learning (e.g., furniture that could be moved easily).

More work is needed to empirically examine the degree to which these practices – as well as other practices that emerged with educators identified as "positive outliers" in the current study (e.g., creating a classroom culture in which high levels of accountability are paired with high levels of care and an explicit focus on building student confidence) – are associated with a variety of positive outcomes. These outcomes should include improved student learning, but also other outcomes including positive teacher and student attitudes about math software, positive student attitudes about math, and heightened student engagement with personalized math software. In doing this work, it will be important to uncover if and how the efficacy of particular implementation practices differs across contexts (e.g., in schools with high vs. low percentages of English language learners) and by student characteristics (e.g., for high-achieving students vs. students who have historically struggled in math). The results of this work will be important in guiding educators on how well-established practices for mathematics teaching in general (see NCTM, 2014; ULEAD Education, 2021) – including establishing learning goals and supporting productive struggle – can be applied to the implementation of math personalized learning software in particular.

Educators who participated in the current study as well as educators who participated in the studies of NGLC schools (Pane et al., 2015, 2017) provide important reminders that effective implementation of math personalized learning software will require commitments from LEAs (see also DeCoito and Richardson, 2018). Specifically, effective implementation will require that educators have the flexibility, time, and resources to, for example,

- √ receive timely school- and grade-level-specific training,
- √ access and use data to inform their teaching,
- √ receive "just in time" support from experts,
- √ experiment with new instructional approaches,
- √ develop strategies to support students individually or in small groups using the immediate feedback provide by software programs, and
- √ collaborate with colleagues and administrators.

The results of the current study provide evidence for a "digital use divide" (Valadez and Duran, 2007). in which some students are using technology in ways that enhance their mathematics learning through student-centered and data- informed teacher support while other students are using technology in ways that lead to student disengagement and educator disaffection. A variety of organizations including the U.S. Department of Education's Office of Educational Technology provide important guidance for identifying and providing the supports necessary for effective technology-supported learning (U.S. Department of Education, 2017).

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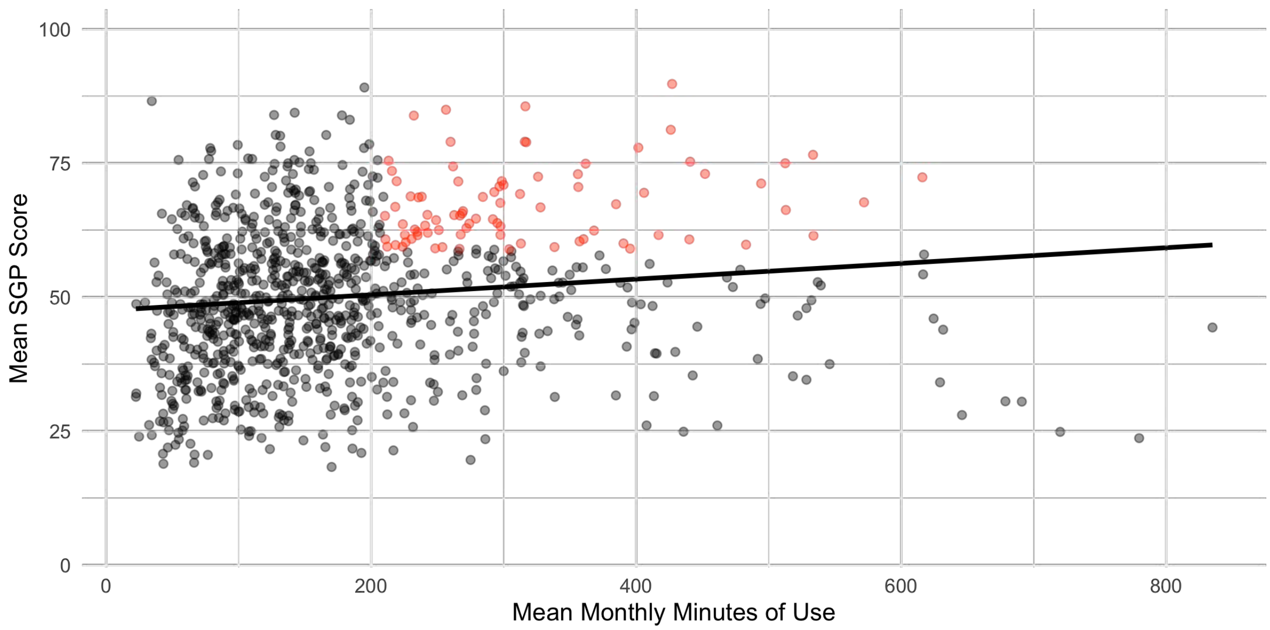
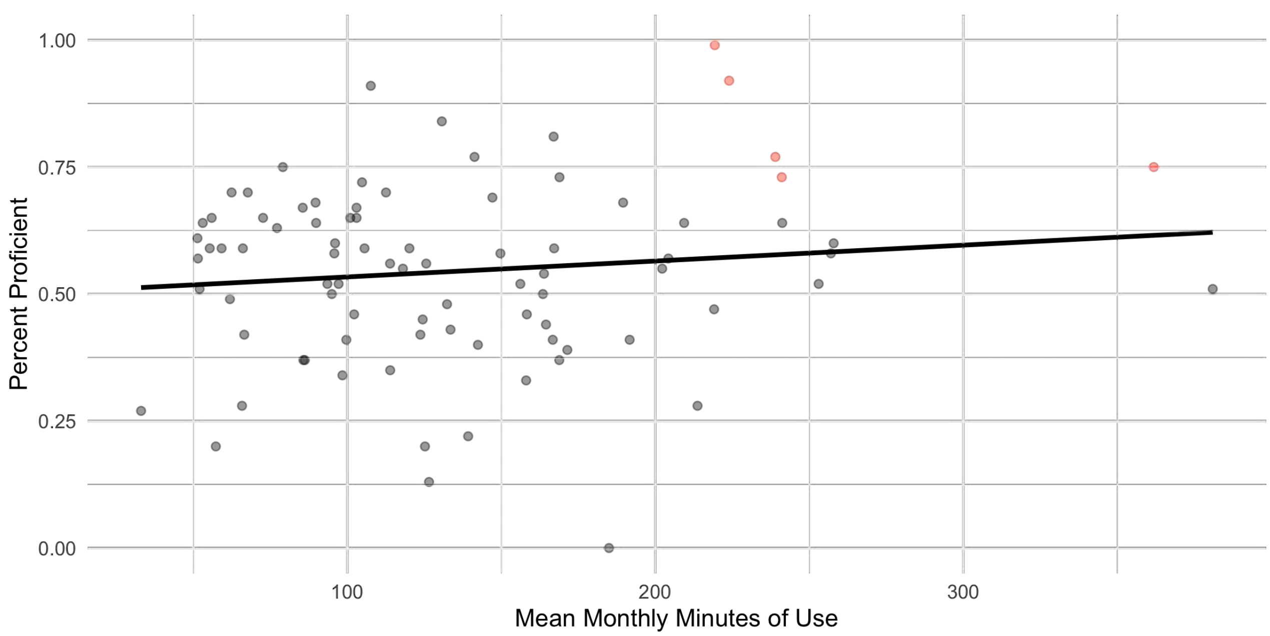
Appendix A. Educators identified as "Positive Outliers" by Vendor and Grade-Level

ALEKS

4th – 8th grade



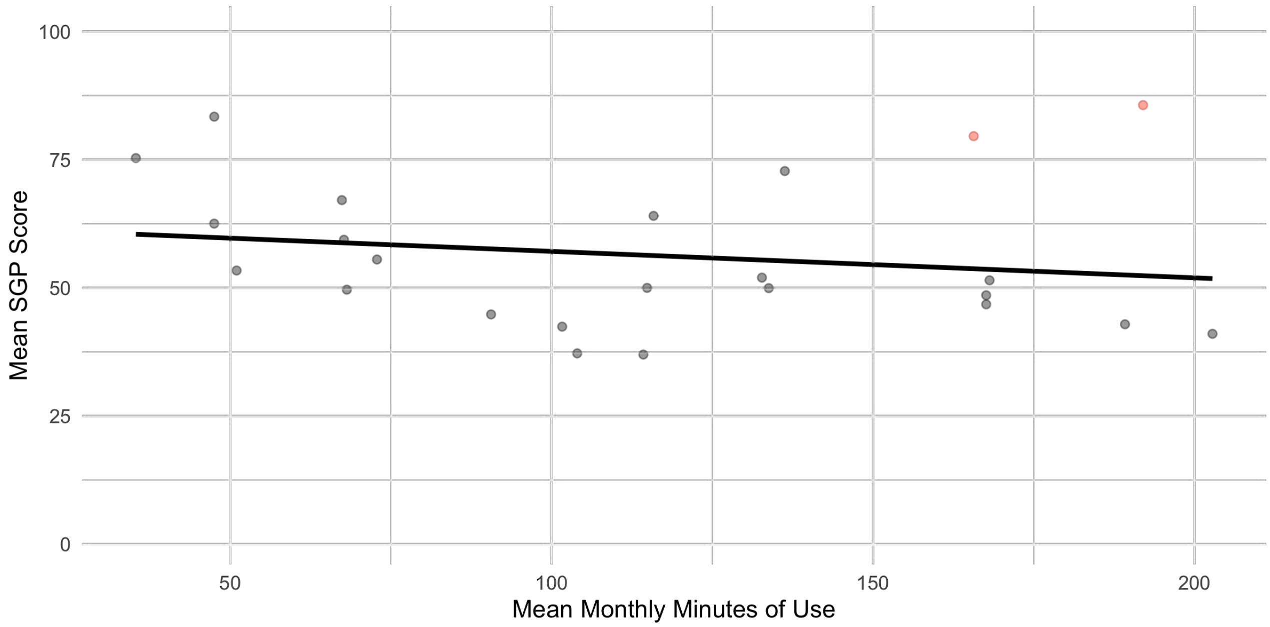
3rd grade



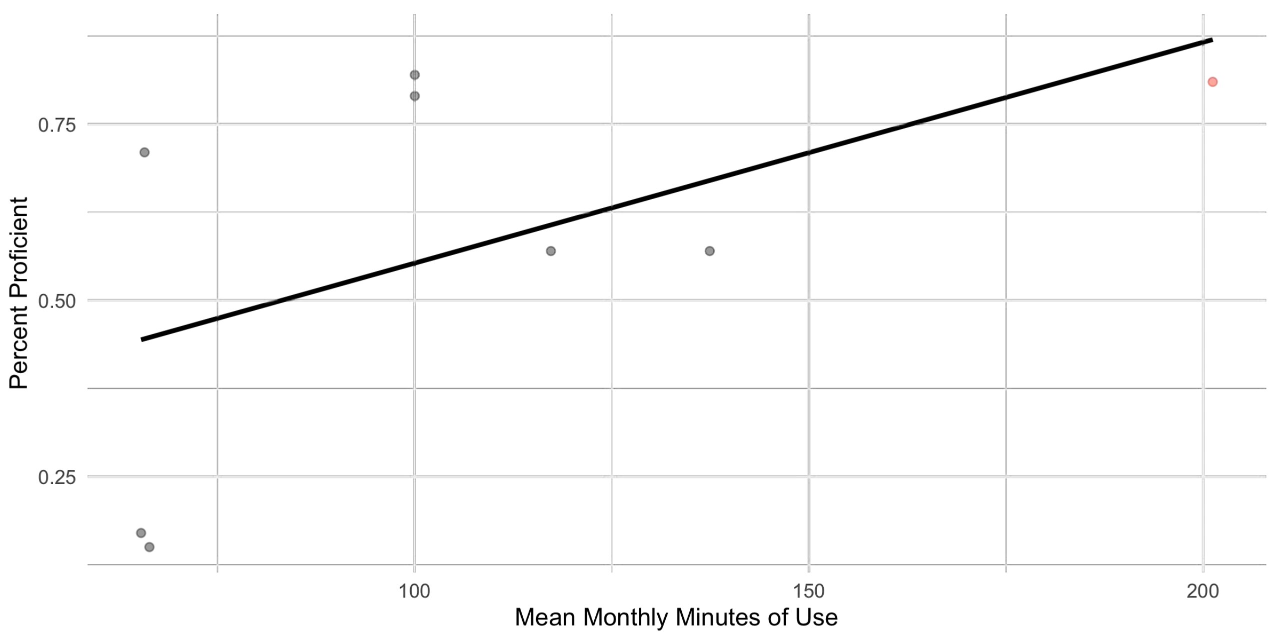
Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

DreamBox

4th – 8th grade



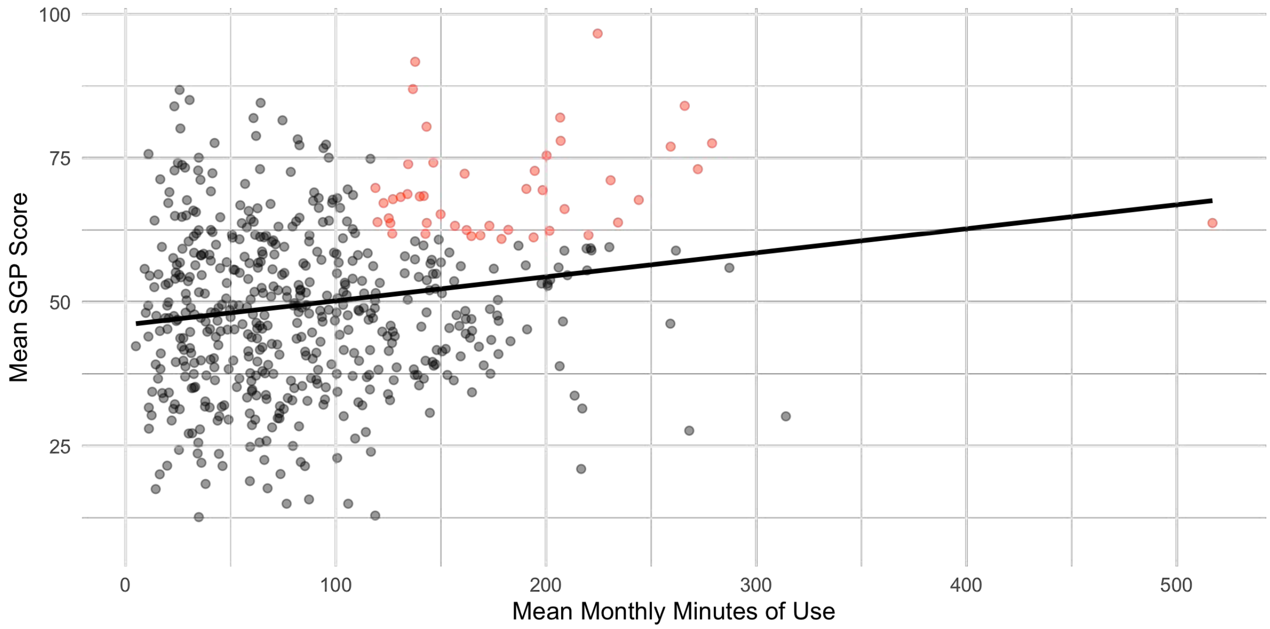
3rd grade



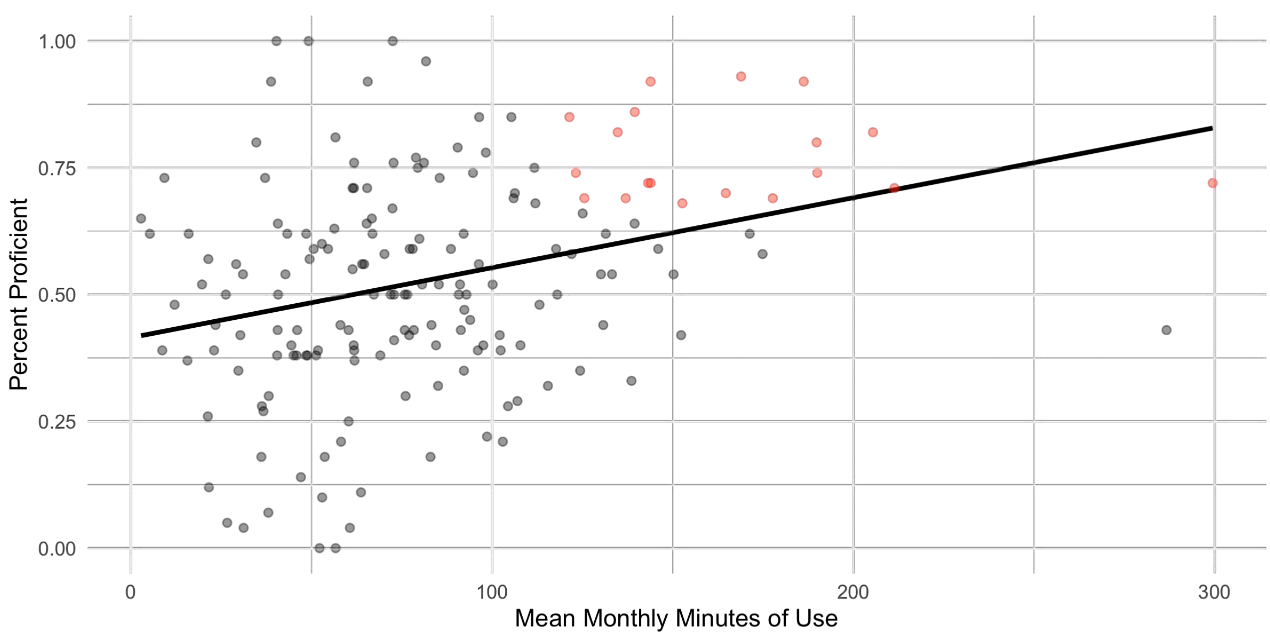
Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

Imagine Math

4th – 8th grade



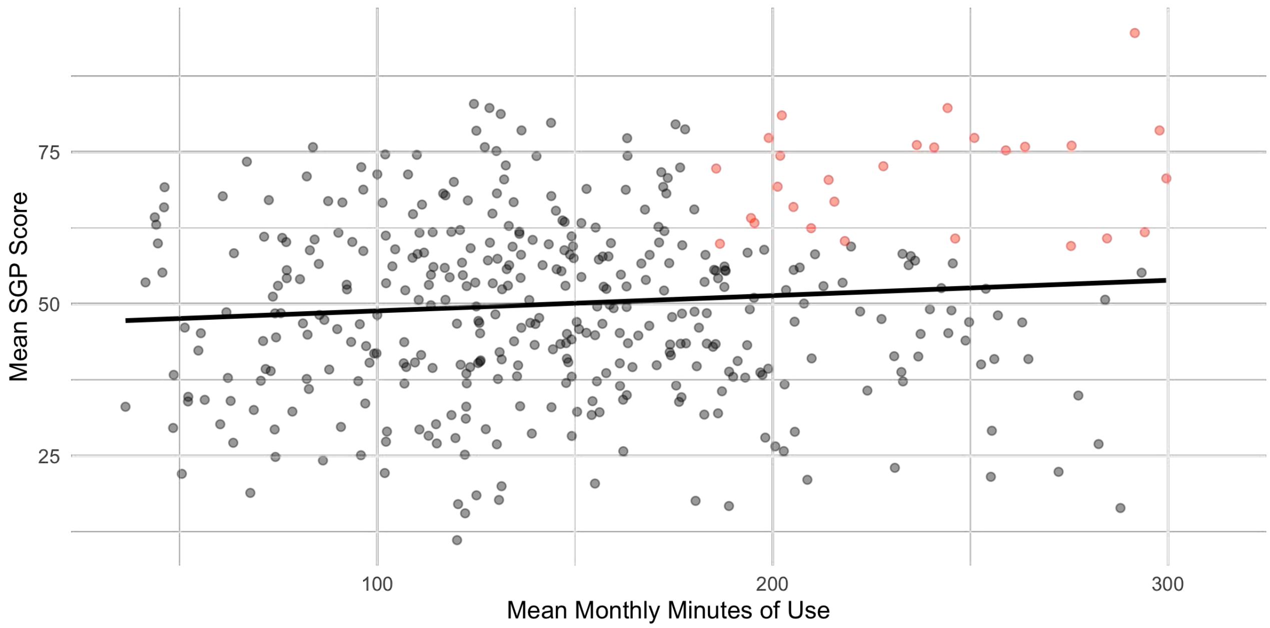
3rd grade



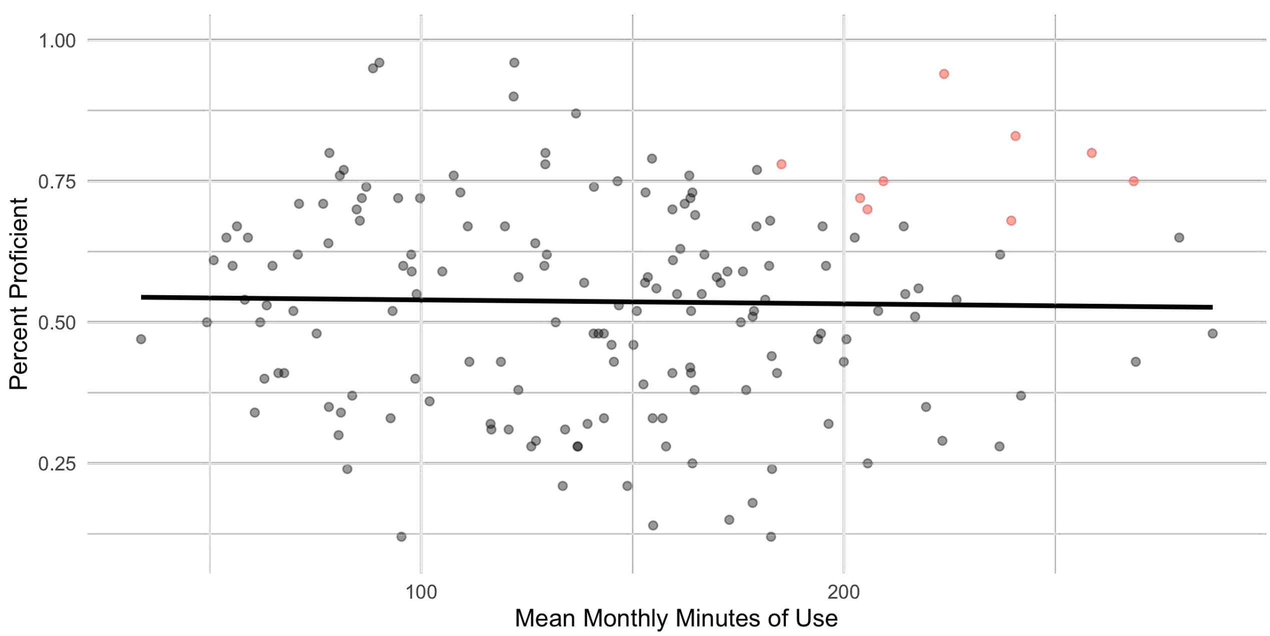
Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

i-Ready

4th – 8th grade



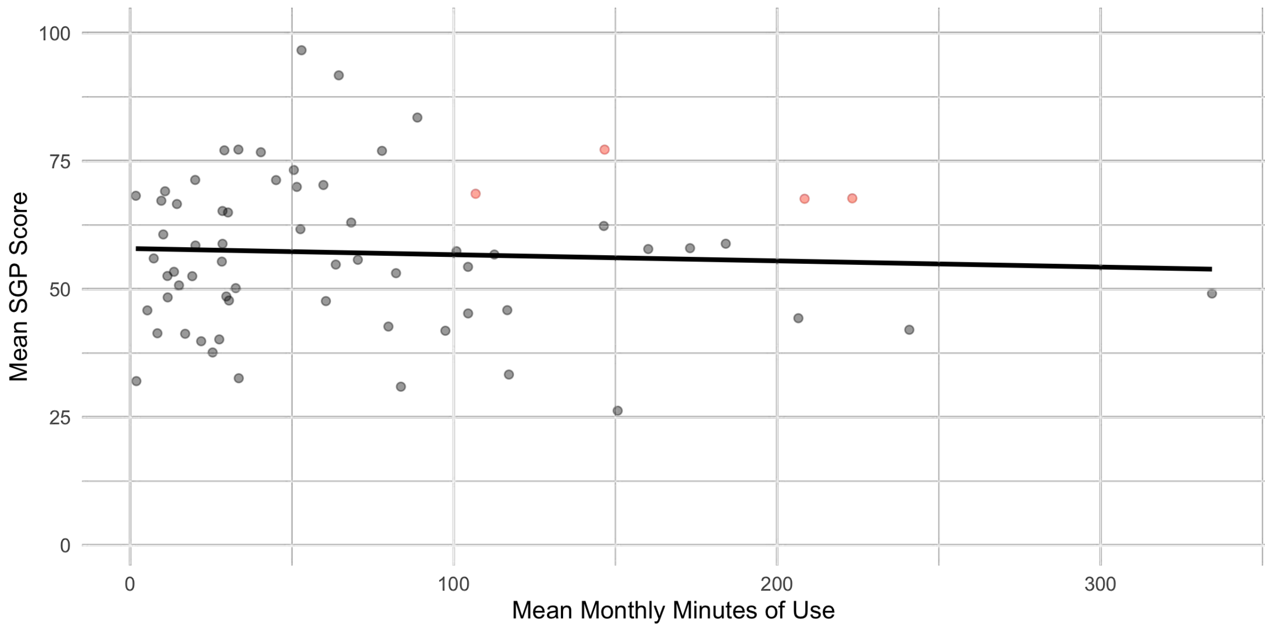
3rd grade



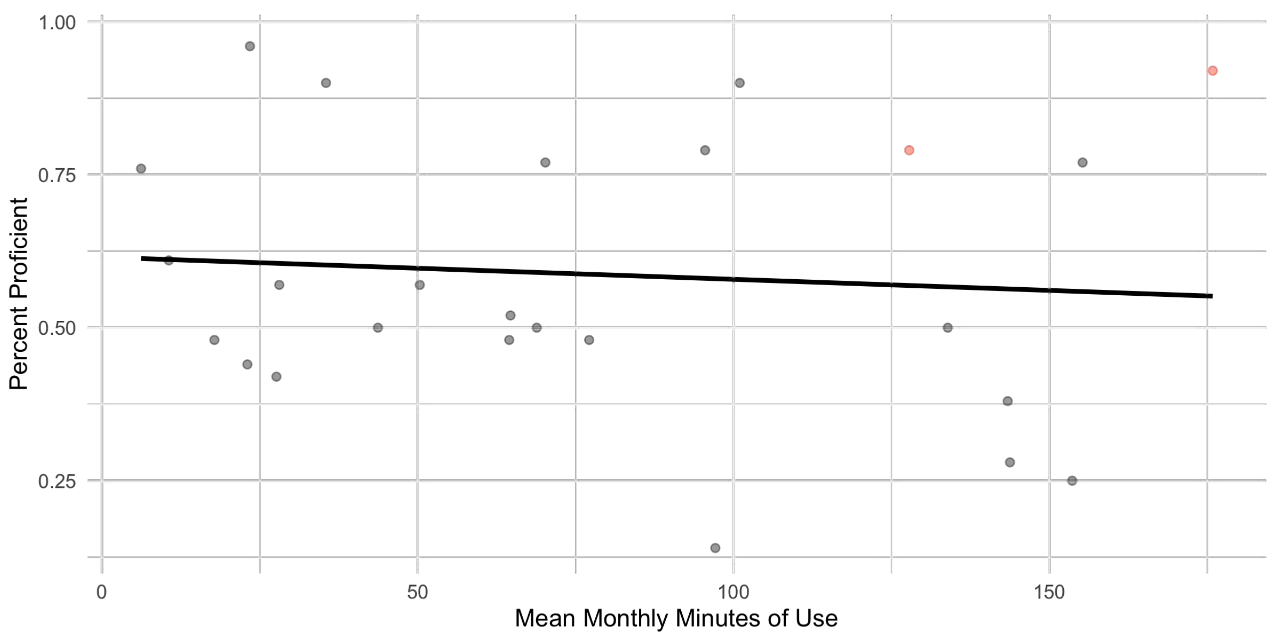
Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

Mathspace

$4^{th} – 8^{th}$ grade



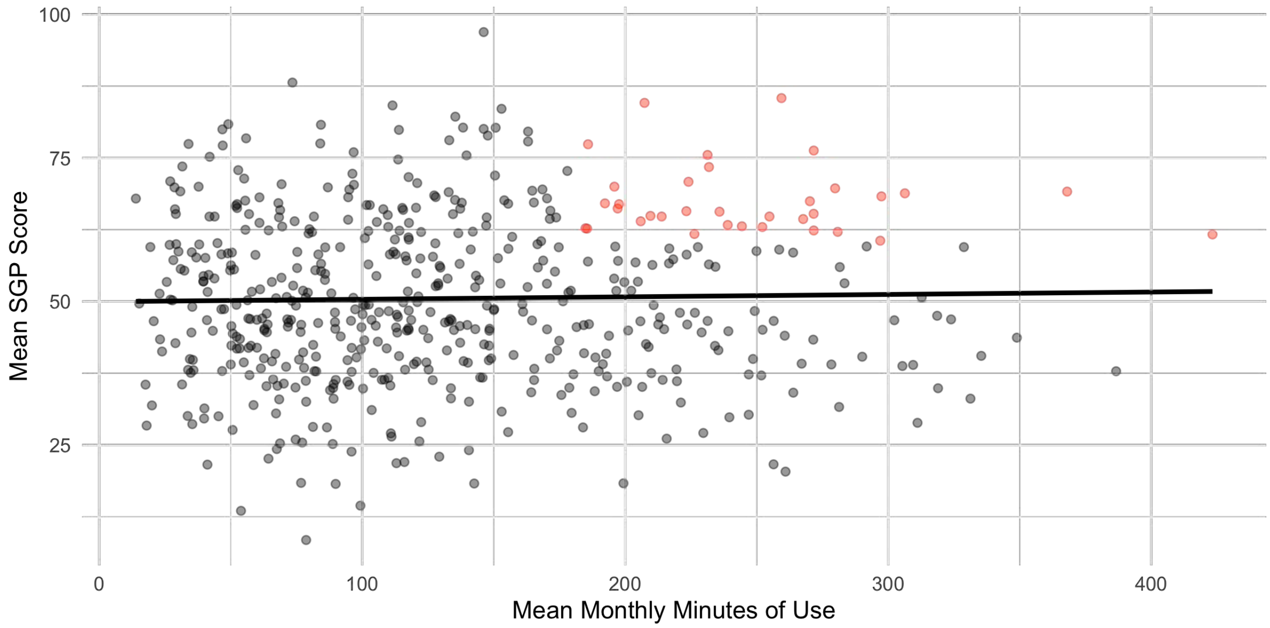
3^{rd} grade



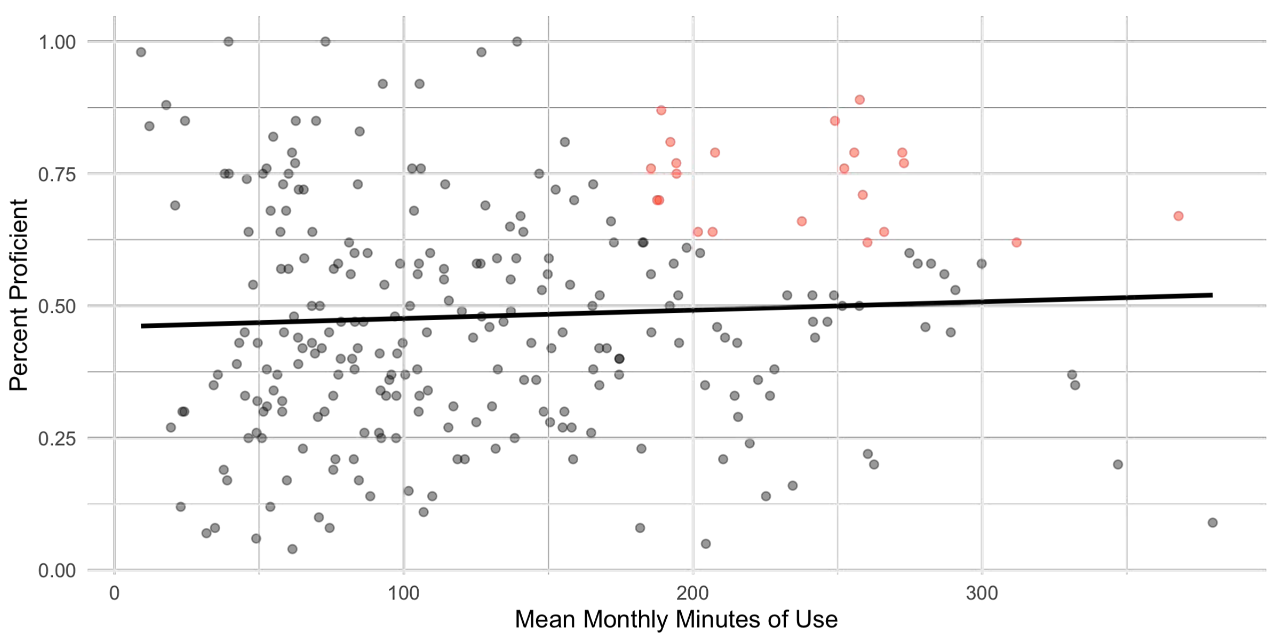
Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

ST Math

4th – 8th grade



3rd grade

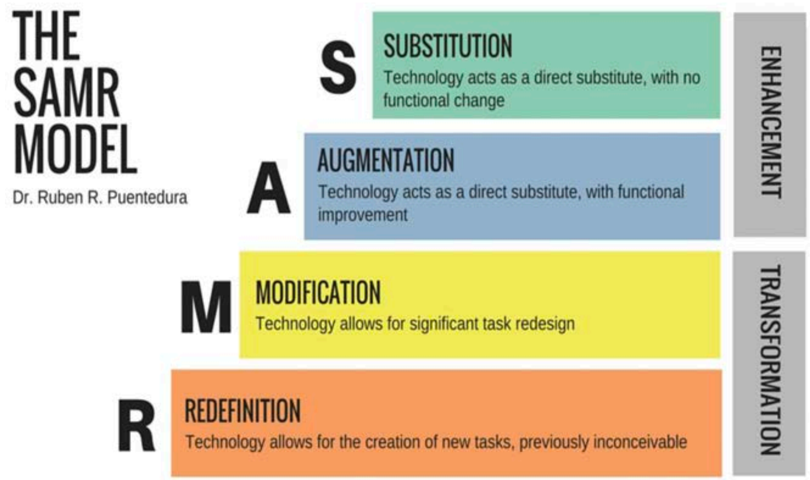


Note. Educators who were in the top 25% of educators on both the engagement metric (i.e., mean monthly minutes of use) and the grade-appropriate achievement metric (SGP scores or percent proficient) are highlighted in red.

Appendix B. Post-Conference Session Facilitation Guide

Post-Conference Session Facilitation Guide

Research Question	Prompts	Facilitation Notes
1. What pedagogical practices do educators who are identified as “positive outliers” view as most impactful when teaching mathematics?	What are the most impactful instructional practices you use in mathematics?	Welcome/Purpose/Create a Dialogue Space **Question #1** Structure: Write/Share/Dialogue
2. How central (or not) is math personalized learning software to the teaching of educators who are identified as “positive outliers” and to the learning of their students?	How and under what conditions do you utilize math learning software? What mathematics achievement outcomes have you seen impacted by your/your student’s use of the math learning software?	**Question #2** Structure: Write/Share/Dialogue [Note that here we are just looking for general descriptions of use. Specific implementation practices will come later.]
3. What specific approaches have worked well for educators identified as “positive outliers” to effectively integrate software into their teaching?	How have you used math learning software to support your instruction? What has worked well for individual instruction or for group activities? What has worked well for differentiation, remediation, enrichment, formative assessment, summative assessment, homework? What do educators need to know about effectively integrating math learning software into their teaching? What supports do educators need to integrate math software into their teaching?	**Question #3** Structure: Write/Share/Dialogue

4. Some have argued that the real power of technology comes not from using it to replace or augment regular instruction, but to transform instruction. What does it mean to educators identified as "positive outliers" to use math learning software in transformative ways?	What does/might it mean to you to purposefully use math learning software in transformative ways? Looking at the SAMR levels, what challenges exist for using the software in transformative ways, that is using the software at SAMR Levels 3 or 4? What kinds of supports would you need to integrate the software in transformative ways, that is using the software at SAMR Levels 3 and 4?	Introduce SAMR Model  **Question #4** Structure: Write/Share/Dialogue

Notes.

All sessions will be audio-recorded. Padlet will be used to document written responses. Participants will receive emails reminding them to bring a laptop. Paper/pens will be available in case there are technology issues.

This resource from the IES can be shared with participants. A key take-home message from this document is that "research has yet to definitively identify the strategies for implementing blended learning that increase the likelihood of positive effects on students." Educators contributions today are an important first step in doing this work!

All participants should be asked to complete an end-of-event survey.