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Implementation of a Mathematics Formative Assessment Online Tool Before and During Remote Learning

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Abstract. ASSISTments is a free online learning tool for improving students' mathematics achievement by providing immediate feedback and hints to students, detailed information on how students performed to teachers, and instructional suggestions for teachers to use. Researchers at the Friday Institute for Educational Innovation conducted an intrinsic, longitudinal multiple-case study of 7th-grade mathematics teachers' implementation of ASSISTments and its impact on their instruction before and during the COVID-19 pandemic. The study examined teachers' use of ASSISTments in three instructional contexts: in-person only, remote only, and both in-person and remote. Our findings indicate that teachers in all contexts changed their instructional practices for homework review and for determining whether their students had understood lessons. Teachers used the ASSISTments auto-generated reports to focus their homework reviews, based on their students' performance, and to provide instructional interventions and/or re-teaching. They also used the instructional suggestions provided by the ASSISTments platform to plan lessons to re-teach concepts or to review prior instruction with their students.

Keywords: ASSISTments, mathematics education, educational technology, teaching support, feedback, formative assessment, data-based decisions.

1 Introduction

The COVID-19 pandemic introduced unprecedented disruption to education in the U.S. Students' achievement in mathematics was more negatively affected than other subjects by the effects of closing schools and turning to remote instruction [1]. Many schools used educational technologies, such as ASSISTments, an online mathematics instructional platform, to maintain learning during school closures. ASSISTments saw significantly increased use during the pandemic, going from supporting 800 teachers to supporting 20,000 teachers and their 500,000 students.

To gain a better understanding of teachers' practices when using educational technologies, and how the learning analytics they provide affect instruction, researchers at the Friday Institute for Educational Innovation (Friday Institute) completed a case

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study exploring how ASSISTments was used during in-person and remote instruction and how, if at all, the use of ASSISTments changed teachers' instructional practices. Researchers were interested in teachers' use of ASSISTments for homework and/or classwork and the impact of ASSISTments on teachers' instructional practices for homework and/or classwork, and in instructional decision-making, in general.

The study's research questions were: (1) *How did teachers implement ASSISTments during in-person instruction and during remote instruction?* and (2) *How did the use of ASSISTments affect teachers' instructional practices during in-person instruction and remote instruction?*

1.1 ASSISTments

The case study is part of a large-scale randomized controlled trial in North Carolina that seeks to replicate the findings of an earlier study, completed in Maine, that examined the efficacy of ASSISTments. The Maine study found that ASSISTments significantly increased students' achievement and changed teachers' instructional practices [2].

The ASSISTments platform contains mathematics questions/problems that teachers may assign to a class of students, to groups of students, or to individual students. The questions/problems are drawn from open educational resources (e.g., Illustrative Math, Engage NY/Eureka Math, Open Up Resources) and there was also the option during the study for teachers to enter their own questions/problems. While completing the assignments, students are given immediate feedback on their accuracy and some problem types also provide hints on how to improve their answers or help separate multistep problems into parts. Once they have completed the assignments, their teachers receive automated reports which provide data regarding how long each student worked, whether they needed multiple chances to answer any question/problem, and whether they asked for hints. Teachers also receive class-level reports showing the accuracy rates of a class per question/problem and whether there were any common wrong answers.

Teachers use ASSISTments to assign online mathematics tasks and to see students' results easily. Teachers can use ASSISTments to assign tasks in class or as homework. By providing individual and class-level reports of students' responses to the tasks and data analysis, ASSISTments allows teachers to quickly assess students' learning. In this way, ASSISTments creates opportunities to use classwork and homework as formative assessments. ASSISTments also provides instructional suggestions to teachers that they may use in re-teaching the whole class, in small group instruction, or in one-on-one instruction.

The ASSISTments theory of change posits that the use of ASSISTments increases the likelihood that teachers will make instructional changes in response to homework results. This process, which is a form of formative assessment, would be described by Duckor and Holmberg [3] as "a dynamic pedagogical process between students and teachers" (p. 336). Research suggests that the use of formative assessment results to make instructional decisions increases students' achievement ([2]; [4]; [5]; [6]; [7]). The ASSISTments theory of change argues that the use of ASSISTments leads to the

use of formative assessment, resulting in teachers making instructional changes based on students' performance. This, then, leads to increased student achievement.

2 Methods and Analysis

This study investigated the implementation of ASSISTments and its impact by gathering data pertaining to teachers' use of ASSISTments and pertaining to their instructional practices both before using ASSISTments and with ASSISTments. Researchers focused on ASSISTments use among teachers of 7th-grade mathematics during in-person instruction and during remote instruction, although some teachers of other grades were also included.

2.1 Survey

In November of 2020 – the second semester of pandemic-response instruction for North Carolina's teachers – the research team invited 544 ASSISTments users in North Carolina to take a Qualtrics survey to share their experiences using ASSISTments both in person and online. Users included those who began using ASSISTments prior to, during, and after the pandemic. The survey asked participants if they had used ASSISTments during in-person instruction, remote instruction, or both, and how they had used ASSISTments (classwork, homework, assessments, other), as well as their plans for future use. Participants were also asked to reflect on factors that made using ASSISTments difficult or easy, as well as their opinions and practices regarding formative assessments and homework. Ninety-seven teachers completed the survey. Closed survey items were analyzed using descriptive statistics. Open-ended survey items were analyzed for themes using an open coding approach [8].

2.2 Interviews

Three researchers reviewed the open-ended responses on the survey to narrow down a pool of potential interviewees. While the researchers looked at all open-ended responses to determine whom to interview, they looked most closely at responses to a question that asked participants to share their definitions of formative assessments. This sampling strategy was used because of the wide variety of individual definitions of the term. The team wanted to understand a wide array of perspectives. However, due to the low response rate to the initial email invitations, the team eventually reached out to all survey respondents who had provided an email address and completed 31 interviews (n=17 both in-person and remote; n=13 remote only; n=1 in-person only). Interview questions encouraged teachers to reflect on their experiences using ASSISTments and asked about: (1) how they used ASSISTments in their instruction; (2) how, if at all, using ASSISTments changed their teaching practices; (3) differences in their use of ASSISTments between in-person and remote instruction; and (4) their perceptions of homework and formative assessments, in general. Interviews lasted between 14 minutes and 37 minutes, and audio recordings were transcribed using Rev.com. The research team used Atlas.ti to analyze the transcripts, determining interrater reliability by coding

three transcripts together. The team established a set of codes based on the interview questions and also used open coding and eclectic coding in the analysis [9]. Multiple rounds of coding narrowed down the findings to themes explained in the next section. To aid in analysis, participants were labeled by the instructional environments in which they had used ASSISTments: in person only, remote only, and both remotely and in person.

3 Findings

3.1 Implementation of ASSISTments

In response to the first study question regarding how teachers implemented ASSISTments during in-person and remote instruction, researchers found that use of ASSISTments remained consistent across instructional environments. The survey indicated that teachers used the program for homework and classwork the most, and the purpose was largely to practice new skills, with reviewing old skills the second-most common purpose. This lack of variability between in-person and remote instruction suggests that ASSISTments is a flexible program which is easy for teachers to access across modes of instruction. This finding was affirmed through an examination of ASSISTments log data and through interviews with teachers.

Researchers noted several changes in the ways that teachers viewed homework more broadly. Teachers indicated that assigning homework through ASSISTments helped them provide more focused assignments for their students. For example, teachers were more selective in which tasks they assigned, choosing to give fewer items each night, but ensuring that each item was aligned with the day's lesson. Interviews also illuminated the tension that existed when students knew their homework was being used as a formative assessment rather than as a graded assignment. When homework "didn't count," some students did not complete the work.

Additionally, remote instructional environments changed teachers' conceptions of homework and classwork. Some teachers said that every assignment during remote learning was homework because they were trying to limit the use of synchronous screen time to direct instruction rather than individual practice. Many teachers noted that they no longer assigned homework during remote learning because they did not want to overburden students with additional screen time, because their students struggled to concentrate in a remote learning environment.

3.2 Impact of ASSISTments

In response to the second study question, results showed that using ASSISTments changed most teachers' instructional practices, regardless of the learning environment (in-person or remote). The survey indicated that 73% of teachers found that using ASSISTments changed how they knew whether their students had understood a lesson. They used the ASSISTments reports to understand where students had struggled and what their errors were. The most common change for teachers was in how they reviewed homework with students. Teachers overwhelmingly agreed that

ASSISTments helped them choose items to review in class that were more targeted to their students' needs. Using the ASSISTments-generated reports, teachers saw which items the students got correct, which they struggled with, and whether there were any common wrong answers.

A few teachers shared that, before using ASSISTments, they were inconsistent in how they reviewed homework and in how they understood students' confusion. Some waited for students to ask questions during class, and others made guesses as to which items they thought were the hardest for their students to answer. Others simply reviewed all the homework items with their students, without knowing how they had performed on them. In implementing ASSISTments, however, teachers analyzed the reports, which showed (1) how many times the students attempted to answer each item, (2) whether they needed to ask for hints, and (3) how long they spent answering each item. These report features gave teachers data to understand which items most students needed to review. The reports also showed teachers if there were any common wrong answers, which helped teachers see if there were misconceptions among the students. This helped teachers determine whether they needed to re-teach a concept to the entire class or to small groups of students.

Most teachers reported using the data from ASSISTments to differentiate instruction and place students into small groups based on their performance. During remote instruction, teachers placed students in virtual breakout rooms and gave them short lessons based on their needs identified via ASSISTments. One teacher provided virtual one-on-one instruction "after school."

Although there were similarities between teachers who used ASSISTments both in person and remotely and teachers who used it only remotely, it was notable that remote-only users (n=13) found that ASSISTments improved their organization and efficiency. These teachers shared that ASSISTments made reviewing students' work easier and timelier, so that students had feedback within 24 hours. Their classes became more efficient and more targeted to students' needs when they used ASSISTments.

4 Significance and Implications

Findings from this study add to the body of knowledge on the use of computer-based platforms to assess students, provide formative feedback to students, and provide usable data for teachers to make instructional decisions. It also adds to the growing body of knowledge on teachers' instructional practices during remote instruction and on instructional practices when moving from in-person to remote instruction. As the pandemic lingers, understanding which instructional practices are used, and how, during remote instruction will assist schools in improving remote instruction. Further, this research is particularly timely as many schools across the U.S. plan to retain virtual "schools" and remote learning options beyond the pandemic.

Our findings also support prior research demonstrating the positive impact of immediate feedback on students' mathematics achievement and the positive impact of the use of formative assessment data to adapt instruction for student achievement. Although this study does not provide achievement results due to the canceled End-of-

Grade Exams, it does indicate how teachers changed their instructional practices when provided with easy-to-access and clear formative assessment results that identify specific areas of student struggle. Schools can keep this in mind when planning professional development and creating data teams. Knowing which practices are likely to occur during teachers' use of specific tools, like ASSISTments, will make it easier for schools to prepare teachers to use them effectively.

This study is also significant in that it demonstrates that a specific instructional tool can change how teachers determine whether their students have understood a lesson. On the survey, 73% of teachers said that ASSISTments had changed how they gauged their students' learning. These findings were reinforced in our interviews, where teachers shared that they were using the reports to determine what they needed to re-teach, which students needed reinforcement on which skills, and whether there were any common wrong answers. This level of understanding is formative assessment at its most effective, allowing teachers to differentiate and personalize students' learning in order to achieve student growth. Teachers also reported using the instructional suggestions provided in ASSISTments, helping them create those targeted instructional activities more efficiently.

References

1. Kuhfeld, M., Tarasawa, B., Johnson, A., Ruzek, E., Lewis, K. Learning during COVID-19: Initial findings on students' reading and math achievement and growth. NWEA (2020).
2. Roschelle, J., Feng, M., Murphy, R.F., Mason, C.A. Online mathematics homework increases student achievement. AERA Open, 2(4), (2016).
3. Duckor, B. Holmberg, C.: Mastering Formative Assessment Moves: 7 High-Leverage Practices to Advance Student Learning. ASCD, Alexandria, VA (2017).
4. Andersson, C., Palm, T. The impact of formative assessment on student achievement: A study of the effects of changes to classroom practice after a comprehensive professional development programme. Learning and Instruction, 49, 92-102, (2017).
5. Chen, F., Lui, A.M., Andrade, H., Valle, C., Mir, H. Criteria-referenced formative assessment in the arts. Educational Assessment, Evaluation, and Accountability, 29(3), 297-314, (2017).
6. Yin, Y., Tomita, M.K., Shavelson, R.J. Using formal embedded formative assessments aligned with a short-term learning progression to promote conceptual change and achievement in science. International Journal of Science Education, 36(4), 531-552 (2014).
7. Polly, D., Wang, C., Martin, C., Lambert, R.G., Pugalee, D.K., Middleton, C.W. The influence of an internet-based formative assessment tool on primary grades students' number sense achievement: Influence of an internet-based formative assessment tool. School Science and Mathematics, 117(3-4), 127-136, (2017).
8. Miles, M.B., Huberman, A.M., Saldaña, J. Qualitative Data Analysis: A Methods Sourcebook. 4th edn. SAGE, Los Angeles (2020).
9. Saldaña, J. The Coding Manual for Qualitative Researchers. 4th edn. SAGE, Los Angeles (2021).