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MATHEMATICS LEARNING LOSS DUE TO INTERRUPTIONS IN FORMAL EDUCATION

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Results from interim benchmark assessment during the COVID-19 pandemic showed that students' performance in mathematics declined at the beginning of the pandemic and worsened by the end of the 2020-21 school year. Further analysis on the data revealed that students in elementary grades registered more loss than students in middle grades. This study explores mathematics learning loss for 48 schools in grades 3-5, focusing more on the domains or goals of mathematics that are tested in these grade levels, to find out if all domains were equally affected.

Introduction

When schools closed in winter of 2020 due to the pandemic, many schools did not immediately go into online mode. Even the few that did, they did so without the instructional expertise. The fact that some students continued with online learning and others did not have any form of instruction during the early days of the pandemic created inequalities in access to learning. By the end of the 2019-2020 school year, many states had put mechanisms in place to ensure that online learning was a means to bridge these educational inequalities. By the beginning of the 2020-2021 school year, measures to mitigate some of the remote learning issues students faced earlier in the pandemic were done by providing computers and in other cases, by having Wi-Fi hubs stationed in areas where students would come and connect to internet. While some schools had online learning and others had in-person learning, a majority of schools provided a hybrid model offering instruction delivery that included both in-school and online learning.

Preliminary fall 2020 reports from Northwest Evaluation Association (Kuhfeld et al., 2020) and other testing organizations showed that student performance during the pandemic was consistent with prior school years in reading but not in mathematics where there was a noticeable decline. By spring of 2021, students' performance showed declines in both reading and mathematics. In addition, students in elementary grade levels registered more loss in mathematics than what was observed for students in middle grades. These reports however, did not focus on the different domains of mathematics to investigate whether the declines in mathematics performance were as a result of uniform declines in all the domains that were tested at grade level

or whether there was a differential performance in the domain. This study seeks to explore if different domains of mathematics were affected differently.

Teaching must move with time and circumstances. Since learning has been disrupted by the pandemic, teachers must be highly adaptive, and data driven. Chang-Bacon (2021) highlighted that the academic success during the pandemic and beyond can be measured through the adjustments schools are making and how these adjustments are affecting learning. Unfortunately, schools and teachers either have no access to data that is useful for decision making or have insufficient data literacy. Adapting to the teaching of Students with Interrupted Formal Education (SIFE) also calls for data-driven professional development. Being quite new to the effects of this pandemic, there is not much research on recovery teaching for SIFE. This study gives the data and tools for professional developers, teachers, and policy makers to continue addressing the math learning loss. The results will also be instrumental in driving policy and helping educators use any available resources from the already depleted resources that many school districts have to target instruction for recovery efforts towards those domains.

Literature Review

The term SIFE in the US has historically been associated with immigrants with limited English proficiency who have had limited formal schooling and are at risk of failing (Costodio & O'Loughlin, 2020, DeCapua, & Marshall, 2011). Hos (2020, p.1022) wrote that "SIFE are students who speak an additional language(s), have entered a U.S. school after second grade, and function at least 2 years below their peers in reading and mathematics." This perspective is also reflected in interventions for SIFE in the US. For example, the New York State Education Department requires that students must first be identified as an English Language Learner before they can be identified as a SIFE.

Significant interruptions to formal schooling are caused by several factors and the effects of learning loss are not limited to immigrants with limited English proficiency. Research has shown that interruptions due to school closures lead to learning loss. For example, closing school for 20 days in one year was associated with lower performance in mathematics. Marcotte and Hemelt (2008) reported that school closure due to snow in Maryland was associated with a reduced number of students with satisfactory performance in math for up to 3%. Similar results were found after school interruptions due to the EBOLA outbreak (Bakrania et al., 2020) and the earthquake in Pakistan (Andrabi, Daniels, & Das, 2021). Significant interruptions can also be

due to being put in juvenile justice facilities (Kubek, Tindall-Biggins, Reed, Carr, & Fenning, 2020), chronic health issues, housing instability, or school closures due to extreme weather (Conto, et. al, 2020).

Thus, this study moves away from the traditional notions that view SIFE as only students who migrated to the US after second grade and are identified as English Language Learners. Rather, we simply conceptualize SIFE as students who have had significant interruptions to their formal schooling. It is within this framing of SIFE that Chang-Bacon (2021) demonstrated that COVID-19 has caused interruptions to formal schooling for many learners creating a generation of SIFE that are not necessarily immigrants to the US or English Language Learners.

Empirical studies on interruptions to formal schooling and learning loss are very scarce (Conto, et. al, 2020). While we can learn a lot from research reports about SIFE who are immigrant ELLs (Chang-Bacon, 2021), the predictions of the effects of school closures on numeracy (Conto et. al., 2021), more empirical studies are needed. For this new generation of SIFE due to COVID-19, Betebenner and Wenning (2021) calls for evidence-based studies that identify the learning loss and how it may be addressed using the following key questions: 1) Who needs help? 2) What do they need help in? 3) How much help do they need?

In an attempt to identify subgroups of students that need help, Store et al. (2022) indicated that low socio-economic students, students of color and students who were not performing well before the pandemic have been hugely impacted by the pandemic.

Data and Methods

This study explores mathematics learning loss for 48 school districts in grades 3-5. All 48 school districts used in this study administer fall and spring Northwest Evaluation Association (NWEA) benchmark mathematics tests to their students in grades 3-5. However, due to the COVID-19 pandemic, they did not administer spring tests in the spring of 2020. In addition, assessment participation rates for spring 2021 were not as high as prior years. Therefore, this study used fall assessment data for three school years – two years before the COVID-19 pandemic (using 2018-2019 and 2019-20 data) and then assessing if the performance was different in the fall of 2020-21 (the COVID-19 pandemic school year).

The overall performance of students in mathematics before and during the COVID-19 pandemic has been discussed to a great extent. However, the performance of students in different domains has not been fully explored. Since we already know that there are declines in overall

mathematics performance during the pandemic, this study will specifically examine the following questions:

1. Are students' experiencing declines in mathematics performance across all mathematics domains within grade levels?
2. Which specific grade levels and domains are of high concern?

In order to answer these questions, the study will use mean score performances and analysis of variance (ANOVA) of student Rasch Unit (RIT) scores to see if the performances pre-pandemic differ significantly from those during the pandemic. In addition to analyzing the overall performance on all domains tested per grade, each domain and grade level will be analyzed separately highlighting mathematics domains in grades 3-5. In all three grade levels (grades 3, 4 and 5), the following four domains of mathematics are tested on NWEA assessments: 1) Operations and algebraic thinking (OA), 2) number and operations (NO), 3) measurement and data (MD), and 4) geometry.

Results

Table 1 shows overall math performance and performance in different mathematics domains in grade 3 for 2018-19, 2019-2020 and 2020-2021 school years. The mean performance in all four domains and overall performance is lower for 2020-2021 school year (during the COVID-19 pandemic) than it was in 2018-2019 and 2019-2020 school years (prior to the pandemic). An in-depth analysis using one-way ANOVA on the performance in all four domains shows that the performance in grade three is significantly lower than it was in prior years on three of the four domains – Operations and algebraic thinking, number and operations, and geometry. However, there was no significant difference in performance on measurement and data where the F-statistic is 2.533, $p = 0.079$). As a result, overall mathematics performance in 2020-2021 school year is lower than the performance in prior years due to the declines in performance in these three domains. In addition, post hoc analysis using Student-Newman-Keuls and Tukey HSD confirm that while performances in the three domains and overall were similar in 2018-2019 and 2019-2020 school years, 2020-2021 math performance in the three domains and overall were different to those from two prior years.

Table 1

Overall and Domain Performance for Grade Three

	2018-2019			2019-2020			2020-2021		
Domain	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
OA	2394	187.3	15.2	2457	187.1	15.5	2233	180.3	17.8
NO	2394	186.6	14.5	2457	186.1	14.4	2233	184.0	17.1
MD	2394	186.6	15.2	2457	185.9	15.0	2233	185.6	16.1
Geometry	2394	188.3	15.5	2457	188.1	15.1	2233	187.1	16.4
Overall	2394	187.2	13.7	2457	186.8	13.6	2233	184.2	14.7

For grade four, the mean overall math performance and performance in different mathematics domains for 2018-19, 2019-2020, displayed in table 2, were higher than those of 2020-2021. In addition, a one-way ANOVA on the performance in all four domains shows that the performance in grade four in 2020-21 is significantly lower than it was in prior years on all four domains of mathematics. F-statistic values in all domains and overall performance ranged from 33.106 to 55.115 with $p < 0.001$ in all cases. This implies that the overall decline in mathematics performance in 2020-2021 school year is not due to one or a couple of mathematics domains – all four domains are significantly affected. Further, post hoc analysis using Student-Newman-Keuls and Tukey HSD confirm that the performance in 2018-2019 and 2019-2020 school years are similar in all four domains and overall performance. However, overall math performance and performance in each of the four domains for 2020-2021 school year was significantly different from prior two school years.

Table 2

Overall and Domain Performance for Grade Four

	2018-2019			2019-2020			2020-2021		
Domain	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
OA	2232	198.8	15.4	2389	198.6	15.8	2297	194.3	18.3
NO	2232	197.4	14.4	2389	197.5	15.0	2297	194.2	17.0
MD	2232	197.0	16.0	2389	196.5	15.9	2297	193.3	16.7
Geometry	2232	198.3	15.7	2389	198.5	15.7	2297	194.7	14.9
Overall	2232	197.9	14.1	2389	197.8	14.4	2297	194.1	14.8

Similarly, the mean overall math performance and performance in different mathematics domains for 2018-19, 2019-2020, displayed in table 3, were higher than those of 2020-2021

school year in grade 5. Also, a one-way ANOVA on the performance in all four domains shows that the performance in 2020-2021 for grade five is significantly lower than it was in prior years on all four domains – Operations and algebraic thinking, number and operations, measurement and data, and geometry. F-statistic values in all domains and overall performance ranged from 6.014 ($p < 0.002$) for number and operations to 92.433 ($p < 0.001$) in geometry. Again, the overall decline in mathematics performance in 2020-2021 school year is due to declines in all of the four mathematics domains that are tested as all four domains are significantly affected. Further post hoc analysis using Student-Newman-Keuls and Tukey HSD confirm that the performance in 2018-2019 and 2019-2020 school years are similar in all four domains and overall performance. However, overall math performance and performance in each of the four domains for 2020-2021 school year was different from prior two school years. It is important to note that while Student-Newman-Keuls considers the performance in number and operations between 2019-2020 and 2020-2021 to be significantly different, Tukey HSD finds that performance not different.

Table 3

Overall and Domain Performance for Grade Five

	2018-2019			2019-2020			2020-2021		
Domain	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
OA	2252	207.6	16.2	2230	206.7	16.2	2166	203.9	17.4
NO	2252	208.0	16.6	2230	207.3	16.8	2166	206.3	18.0
MD	2252	206.2	17.7	2230	205.2	17.4	2166	202.1	17.9
Geometry	2252	207.9	16.6	2230	207.3	16.9	2166	201.7	16.5
Overall	2252	207.4	15.7	2230	206.6	15.7	2166	203.5	15.8

Discussion

Using the definition of SIFE as students whose formal schooling has been significantly interrupted, the study sought to identify the grade bands of students who have shown significant decline in mathematics performance. It also sought to identify the NWEA's mathematical domains whose performance declined during the COVID-19 school interruption. In grade three, the effects of the pandemic are seen in operations and algebraic thinking, number and operations, geometry but not in measurement and data. However, performance declined in both fourth and fifth grade mathematics is in all domains. It is important to not overgeneralize and correlate the

trend of the decline with increase grade levels. Further analysis for data, not included in this paper, showed that only grade 4 to 6 had declines in all domains. Grades 7 and 8 had declines in some domains but not all.

While other researchers have addressed part of the framework for this study on identifying who needs help, this study has established that students need help in almost all of the domains in mathematics in grades 3-5. The study provides significant information on the domains which policy makers, educators, and other stakeholders need to focus on and put more resources to improve mathematics performance. As we address the needs of SIFE whose school interruption is due to COVID-19, it is important to acknowledge that resources in the field of education for SIFE already exist (Freeman & Freeman, 2002). Lessons from and resources for educating SIFE including those experiencing housing insecurities, natural disasters, punitive suspensions, incarceration, or chronic health issues can be repurposed to address interruptions due to the COVID-19 pandemic (Chang-Bacon, 2021, Schilling & Getch, 2018).

In exploring the mathematics performance of SIFE due to COVID-19, this study has not analyzed the data for different demographic groups. In a predictive study of the effects of school interruptions due to COVID-19 that was based on data from 174 countries, Azevedo (2021, p.1) wrote that "Exclusion and inequality will likely be exacerbated if already marginalized and vulnerable groups, such as girls, ethnic minorities, and persons with disabilities, are more adversely affected by school closures". This is consistent with Store et.al (2022) findings that have been discussed already. However, more studies need to be done using newer data to examine if the gaps in performance between students of different demographic backgrounds are getting better or if they are getting wider.

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