Examining the Influence of COVID-19 on Elementary Mathematics Standardized Test Scores in a Rural Ohio School District

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In the United States, national and state standardized assessments have become a metric for measuring student learning and high-quality learning environments. As the COVID-19 pandemic offered a multitude of learning modalities (e.g., hybrid, socially distanced face-to-face instruction, virtual environment), it becomes critical to examine how this learning disruption influenced elementary mathematic performance. This study tested for differences in mathematics performance on fourth grade standardized tests before and during COVID-19 in a case study of a rural Ohio school district using the Measure of Academic Progress (MAP) mathematics test. A two-way ANOVA showed that fourth-grade MAP mathematics scores were statistically similar for the 2019 pre-COVID cohort (n = 31) and 2020 COVID-19 cohort (n = 82), and by gender group, between Fall 2019 and Fall 2020. Implications for rural students' academic performance in virtual learning environments are discussed.

Keywords: COVID-19, elementary mathematics, rural school districts, gender, mathematics performance

Introduction

The COVID-19 pandemic vastly altered the educational learning environment as emergency online instruction became the norm and school districts focused on developing digital-friendly classroom platforms. At the same time, educators encountered challenges with student absenteeism, classroom engagement, and instructional quality (Ligon IV, 2021). Transitioning to digital learning required educators' reliance on technologies to teach abstract concepts and content. Studies showed that teachers' technological proficiency determined the extent to which they utilized technological tools; it also influenced their sense of teaching efficacy in providing mathematics lessons in a digital setting (e.g., Fernandez & Forde, 2021; Ladendorf et al., 2021). Research qualitatively illustrated how mathematics educators used technology to implement creative methodologies and approaches to model problem-solving and mathematical equations (Eisenbach et al., 2020).

Students' scores on standardized tests from before to after the onset of COVID-10 have been studied as one indicator of the impact of the pandemic on student performance (e.g., Donnelly & Patrinos, 2021). Any decline in students' scores is broadly referred to as "learning loss" in the literature adapted from the term "summer learning loss" (e.g., Cooper, 2003). Early into the pandemic, several studies offered projections into *how much* change in students' scores educators should expect throughout the pandemic (Betebenner & Wenning, 2021; Kuhfeld et al., 2020). Preliminary projections showed that declines in students' scores due to COVID-19 were greater than the rate caused by other phenomena that the literature has previously explored, such as absenteeism and summer break (Kufheld et al., 2020).

It is important to investigate the influence of COVID-19 on elementary students' mathematics performance in particular as a significant predictor of later mathematics achievement (Rabiner et al., 2016; Siegler, 2012) and long-term literacy or reading skills (Kim et al., 2016; Purpura et al., 2017; Ribner et al., 2017). Additionally, research has found that fourth-grade mathematics performance is as reliable of a predictor for graduation outcomes as ninth-grade mathematics performance (Betts & Zau, 2008). Further, early mathematics ability is associated with the likelihood of successful completion of high school (e.g., Balfanz et al., 2007), college attendance (e.g., Davis-Kean et al., 2021) and STEM interest (e.g., Fong et al., 2020).

Despite the importance of early mathematic performance on later achievement, research on the differential influences of COVID-19 on mathematics performance is limited. The existing pre-COVID-19 literature has shown differential elementary math outcomes based on gender and geographic locality (e.g., Graham & Provost, 2012; Rodriguez et al., 2020; Sovia et al., 2019). Findings are largely mixed on whether gender differences exist in elementary math education. Some research indicated gender gaps in math performance, with males scoring higher than females (Daucort et al., 2021; Reardon, 2019; Zhou et al., 2017), while other studies found no gender gap in math performance (Hyde et al., 2008). In terms of geographic area, the pre-COVID-19 research shows a positive correlation between academic achievement and locality wealth (Reardon, 2019). Rural students from wealthier regions (e.g., the Northeast region) have demonstrated higher achievement outcomes on standardized tests than their rural peers from lower-income communities (Reardon, 2019).

As fourth and eighth grade levels are critical years for testing students' academic growth and performance, the literature commonly examined these academic years (Nelson et al., 2016, Robinson & Dervin, 2019). However, research has paid greater attention to eighth grade assessment performance (Stack & Dever, 2021) as this grade level is a transitional period to high school. Thus, fourth grade, another common testing year, is left underexplored. Furthermore, few studies exist that examine math performance at the fourth-grade level in a rural context with an asset-based framework.

Spruce Mountains Local School District[1] (SMLSD), located in rural Ohio, is one case of a rural school district that is atypical to the literature's description of rural schools as lagging behind their urban and suburban counterparts (Lindahl, 2012; Pawar & Shinde, 2016). Because of the nature of this case, SMLSD was chosen to highlight the importance of asset-based framing. The

[1] Pseudonym.

current study examined SMLSD's fourth-grade students' mathematics performance across males and females from before to after the onset of COVID-19 in a rural school district. This study contributes to the body of research by illuminating the growing need to disaggregate rural district mathematics data. Within the context of this study, mathematics performance was defined as students' Rasch unIT (RIT) scores on the Measure of Academic Progress (MAP) mathematics test (Northwest Education Association [NWEA], 2020). Two research questions were addressed:

1. Was there a statistically significant difference between SMLSD's fourth grade 2019 pre-COVID-19 cohort and SMLSD's fourth grade 2020 COVID-19 cohort's Fall MAP mathematics average RIT scores compared to the national norm scores?

2. Was there a statistically significant interaction between the effects of cohort (2019 pre-COVID-19 or 2020 COVID-19) and gender group on SMLSD's fourth grade 2019 and 2020 Fall MAP mathematics average RIT scores?

COVID-19 Disruptions to Elementary Mathematics Instruction

The "emergency remote teaching" (ERT) at the onset of COVID-19 brought challenges to under-prepared teachers in the online or hybrid instructional environment. Pre-pandemic literature reviews suggested challenges associated with online/remote teaching for those more customed to face-to-face instruction, including but not limited to the changing roles of teachers, time management, different teaching styles, online content development, and technology integration (Kebritchi et al., 2017; Moore-Adams et al., 2016). More recent studies on COVID-19 teaching reveal similar challenges resulting from disruption to traditional instruction by the pandemic. Teachers experienced obstacles in terms of content creation for online spaces, new delivery technologies/tools, online pedagogy, parental engagement, and student mental health issues (e.g., Ferri et al., 2020; Hartshorne et al., 2020). Additionally, the pandemic disrupted traditional paper-pencil-based and face-to-face assessments, limiting teachers' timely access to information on their students' learning outcomes and academic progress (Burgess & Sievertsen, 2020) if online/remote assessments were not an option. These influential learning disruptions were coined "test pollution," which refers to the systemic "increase or decrease in test scores unrelated to the content domain" (Middleton, 2020, p. 2). COVID-19 and the resulting disruptions acted as a factor in standardized test outcomes (Middleton, 2020).

COVID-19 Disruptions to K-12 Mathematics Performance

Disruptions caused by COVID-19 go beyond elementary mathematics instruction and impact students' mathematics performance. The forced school closures in over 160 countries to mandate temporary closure (World Bank, 2020) disrupted student learning at various levels. The reduced face-to-face institutional time led to potential learning loss, defined as declines in student knowledge and skills (Pier et al., 2021). Donnelly and Patrino's (2021) report suggested that learning loss happened across a range of subjects, grade levels, and regions during the pandemic. For example, NWEA (2021) noted that while median achievement declined for all students in reading and math from Fall 2019 to Fall 2021, the magnitude of the decline was larger for Hispanic, American Indian and Alaska Native, and Black compared to Asian American and white students. Further, historically marginalized student populations and elementary grades were disproportionally affected (Lewis & Kuhfeld, 2021; NWEA, 2021).

Before the pandemic, researchers started investigating the impact of different learning modalities on mathematics learning and test-taking. Online learning, in general, has been found to offer learning advantages such as personalization, flexibility, and repeatability when done well (e.g., Brecht & Ogilby, 2008; Hwang et al., 2021; Lee, et al., 2009). However, potential disadvantages have been found to this teaching modality including lack of interactions, low-quality interactions, and difficulty seeking help associated with learning online (e.g., Dumford & Miller, 2018). Research has shown no significant difference in long-term mathematical knowledge retention between online and face-to-face learning environments among middle school students (Edwards et al., 2017). However, most studies on online learning focus on higher education and adult education (e.g., Bailey, 2020; Hwang, 2018; Raes et al., 2020). The literature is severely lacking research on mathematical knowledge retention based on environment (e.g., remote or face-to-face) for elementary-aged children. As many elementary children engaged in online learning during the COVID-19 pandemic, it is imperative to investigate different learning modalities for mathematics learning and test-taking.

Differential Effects on Mathematic Performance for Rural Districts

Before COVID, research showed mixed results for differences in mathematics performance by gender groups and geographical location (Alkhadim et al., 2021; Alordiah et al., 2015; Logan & Burdick-Will, 2017; Showalter et al., 2019). Some studies found no difference in mathematics scoring between students in rural and nonrural districts (Esplin et al., 2020; Williams, 2005), while other studies identified a difference, with nonrural schools having higher academic performance (Irvin et al., 2017). However, these studies fail to examine regional differences in mathematics performance. Rural regions may have different resources, albeit, they are all bound by the demographic features of their geographic environment. Thus, rural mathematics performance should be evaluated in a within-group context, or compared across different rural regions (e.g., West, Northeast, South, and Midwest; Malkus, 2018) because it allows us to understand math performance in similar settings.

Despite variations within and across rural school districts, rural mathematics performance data is aggregated in much of the discourse (e.g., Agger et al., 2018; Logan & Burdick-Will, 2017; Miller et al., 2019; Votruba-Drzal et al., 2016). Illustratively, Malkus (2018) used the National Assessment of Educational Progress (NAEP) data to examine fourth grade mathematics performance across the country. It was concluded that there was “more regional variation *within* the rural student scores than *across* localities nationally” (Malkus, 2018, p.17). This finding is important in the elementary mathematics performance discourse, yet few other studies differentiate student progress by region and locality. Such a gap in the literature offers an opportunity to discuss, and highlight, mathematics performance for a region beyond a deficit framing. Although, this study does not seek to compare rural school districts across localities, we do seek to illuminate the value of examining this unique rural context.

COVID-19 was a form of learning disruption for students across the country (Reimers, 2022). So far, little literature explores the influence of COVID-19 on rural elementary mathematics learning environments, specifically in the United States at large. To date, a dearth of literature explicitly explores how elementary rural students’ mathematics performance fared during COVID-19 learning in the United States context. Xie et al. (2021) evaluated the concept of micro-classes in a global context for primary school mathematics courses. The study sought to glean primary school-aged children's satisfaction with these micro-classes. Elementary-school-aged children were found to have positive opinions toward these classes in urban and rural settings. This study indicated that elementary-aged children did not perceive a difference in learning information between small virtual classroom settings and face-to-face classrooms. However, Zeng and Luo (2021) explored learning outcomes for rural students in western China during online learning. They found that these students experienced a drop in mathematics performance during COVID compared to before COVID. These findings do not bode well for students in rural localities; however, these studies are not in the United States context. Therefore, these findings cannot be generalized.

Gender and Mathematics Performance

Taken together, results from the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) show gender differences in mathematics performance continue to persist. These two assessments allow for an inspection of various age groups and mathematics domains. While fourth graders and 8th graders take the TIMSS, the PISA is taken strictly by 15-year-old students. Furthermore, the TIMSS focuses on a common set of mathematics standards while the PISA emphasizes students' problems in life (Gronmo & Olsen, 2006).

Despite the gap between males and females closing globally, a scoring difference exists on large-scale tests such as the PISA and the TIMSS for mathematics. As recently as the 2018 PISA results, 15-year-old males scored an average of 5 points higher than 15-year-old females in all OECD countries, but this difference grew to 9 points when looking at the United States (OECD, 2019). Examining mathematics results from the TIMSS showed no significant difference between eighth-grade males and females. However, there was a statistically significant difference between fourth grade males and females in 2019 of eleven points, in favor of male students. Furthermore, this disparity between male and female fourth grade math TIMMS scores has grown substantially from three points in 1995 (TIMMS, 2019).

Differences in standardized testing outcomes illustrate an opportunity for further research to determine whether such testing is most appropriate to evaluate mathematical ability and inquire about the underlying causes of these differences. Moreover, the COVID-19 pandemic may have influenced standardized mathematic performance, but research has yet to offer empirical data on the impact of COVID-19 on standardized mathematic performance. This gap in the literature presents an opportunity to evaluate whether learning during COVID-19 has produced male-favoring, female-favoring, or gap-closing effects on mathematics.

Differential Effects on the Intersection of Locality and Gender

Although there seems to be a gap in the literature of studies that examine gender equity in rural elementary mathematics classrooms, several studies evaluate gendered differences in mathematics performance based on *socioeconomic* status and familial contexts at different geographic scales (Hopcroft & Martin, 2016; Legewie & Diprete, 2012; Trivers & Willard, 1973). As this study differentiates rural localities based on their socioeconomic status (SES) and resource capacity, this literature review component utilizes SES as a proximity to evaluate the intersectionality between gender and mathematics performance based on a rural locality's SES. Reardon et al. (2019) explored gaps in mathematics and English tests for elementary through eighth grade students across the United States. They found gender-based gaps throughout the country, but whether they were male-favoring or female-favoring was based on the school district. Of particular interest to this study, male-favoring gaps were concentrated in socioeconomically advantaged school districts (Reardon, 2018; Reardon et al., 2019).

As the COVID-19 pandemic transitions from shutdown to life more similar prior to 2020, it is important to consider more than the locality of students, but also the context and background of these students. We don't know whether the COVID-19 mitigated male-favoring gaps in socioeconomically advantaged school districts, thus, additional research is needed. As there is little research exploring this specific nuance, this study offers an opportunity to examine whether mathematics differences present themselves for this rural population in a socioeconomically advantaged school district.

Context of Present Study

Demographic Characteristics

The SMLSD is a K-12 rural school district comprised of four schools and serves more than 1,300 students. The median household income within the district area is $68,886, which is approximately 10% higher than the county median income ($63,092). As a rural school district with relative means, Spruce Mountain was able to equip classrooms with the latest technology, including Macintosh computers, Chromebooks, and iPads.

Regarding the school district's racial and ethnic demographic, 90% of students are white, 8% are Hispanic or Latinx, 1% are two or more races, and 1% are Black/African American. In the school district's region, 33% of students are eligible for free and reduced lunch. Approximately 13% of students in SMLSD have an IEP or receive special education services. The greater Spruce Mountains community speaks predominantly English (99%) and is predominantly white (95%).

Attendance and School Operations During COVID-19

In the 2020-2021 academic school year, the SMLSD fully reopened with in-person classes and safety protocols in place (e.g., masks, sanitization, spacing seats). For families that preferred a virtual setting, the school district developed a fully virtual school option and approximately 120 students were enrolled during the 2020-2021 school year. Thus, some classes were slightly smaller. Social distancing was implemented throughout the day in the classroom, but some teachers would shift to small group instruction during the school day in which social distancing was not practiced. Teachers indicated that their primary concern was to provide students with small group instruction, especially at the primary grade level.

Curriculum, Instruction, and Assessment During COVID-19

Prior to the COVID-19 pandemic, the academic curriculum utilized digital content when appropriate based on individual student needs. During Spring of 2020, when the pandemic-initiated school closures, classes transitioned to a digital learning environment, Google

Classroom. Teachers utilized Google Classroom to embed digital curriculum resources into their classrooms within the district. Some classroom teachers provided class Zoom meetings, individual Zoom time, and/or adjusted their day to provide instructional support in the evenings to help parents support their students' learning. Teachers also utilized the digital resources available in the district-adopted curriculum resources, and others implemented additional technology-driven resources. The district provided educators with curriculum resources, but the extent to which teachers adapted these digital resources depended on the teachers' comfort level and knowledge of technology.

Both pre-COVID and during COVID-19, there was a combination of digital and paper/pencil assessments. The choice of format was largely contingent on teacher and type of course. There were no differences in how testing was administered between these two time periods. The district adjusted schedules for virtual students to accommodate state mandated assessments by allowing students to test afterschool in small groups, spread out in the media centers. This context offers rich data to examine the important variables that may support positive academic outcomes.

The conditions of the rural school district in this study illustrate the value of social capital, which Yosso (2005) defines as "networks of people and community resources [that can provide support] to navigate through society's institution" (p. 79). In the context of this study, we focus specifically on school social capital. The classroom's learning climate and the students' demographic background are the structural components of SMLSD that influence how much social capital appears (Stockard & Mayberry, 1992). In principle, this study draws on rural education's social capital, such as the unique learning environment with small classrooms, quality educators, engaged parents in students' learning, and high expectations of students.

Methods

Research Design

A causal-comparative research design was used as this type of study allows "to retroactively study differences" in MAP Mathematics RIT average score, and potential variations, (e.g., demographic features), "within a context and among groups" (Fulmer, 2018, p. 253). Additionally, the independent variables, gender and cohort, had non-random assignment and their group affiliation could not be manipulated (Salkind, 2010). Thus, a causal-comparative research design was most appropriate.

Instrumentation and Data Collection

Mathematics performance of fourth grade students in the SMLSD was assessed using the MAP, validated measures widely adopted and shown to have strong validity evidence for measuring student learning (e.g., January & Ardoin, 2015). Since MAP's inception to the educational standardized testing field in 2000, it has been widely used to assess student growth, and teaching practices and as a predictive validity tool for other assessments of mathematical ability (e.g., Boorse & Van Norman, 2021; Klingbeil et al., 2015; Pomplum, 2009). As of 2022, MAP testing is used across all 50 states to varying extents, with some states approving the assessment for statewide testing and other states utilizing school district discretion. The MAP Mathematics assessment has moderately shown individual variability yearly and small monthly growth for students (Boorse & van Norman, 2021). These MAP assessments are psychometrically validated measures that have been widely adopted and shown to have strong validity evidence for measuring student learning (e.g., January & Ardoin, 2015). The metric used for the MAP assessments, RIT, is an equal interval scale that translates students' responses into a data value on the RIT scale between 100-350 (Marion, 2021). Moreover, to publish the most reliable and valid national norm scores, MAP uses the 4th week of school for Fall norm score setting, the 20th week of school for Winter norm score setting, and the 32nd week of school for Spring norm score setting (NWEA, 2020).

Mathematics assessment demographic data were provided to the researchers by the Spruce Mountains Local School District. Student-level MAP Mathematics RIT average scores were reported as a composite score of student performance across sections on the MAP (Measurement and Data, Geometry, Number and Operations, Operations and Algebraic Thinking).

Sample

All fourth grade students (N=113) from the SMLSD were in the sample for this study. The total sample (N=113) comprised a larger 2020 COVID cohort (73%) than 2019 pre-COVID-19 cohort (27%), and slightly more male students (58%) than females (42%). For the 2019 pre-COVID-19 cohort, 31 fourth graders took the MAP Mathematics RIT assessment. Of these 31 students, 13 students were female (41%) and 18 were male (58%). In the 2020 COVID-19 cohort, 82 fourth grade students took the MAP Mathematics RIT assessment. Of the 82 students, 35 were female-identifying (43%) and 47 were male-identifying (57%).

Data Analysis

A 95% confidence interval was used for all statistical analyses with an alpha set at .05 (two-tailed). One-Sample Z-tests were conducted to address the first research question. A One-Sample Z-test is used to compare a sample mean to a population mean when the population variance is known (Wooditch et al., 2021). Subsequently, two One-Sample Z-tests were used to compare the 2019 pre-COVID-19 cohort's mean to the national norm score and the 2020 COVID-19 cohort's mean to the national norm score. Based on the most recent norm study conducted by the NWEA (2020), the national Fall MAP Mathematics Average RIT norm score is 199.5 (SD = 14.40).

A 2 x 2 two-way analysis of variance (ANOVA) was conducted to address the second research question. Two-way ANOVA tests for interaction and main effects across two or more categorical independent variables on a continuous level dependent variable (Mertler & Vannatta, 2017). The two independent variables were cohort (2019 pre-COVID-19 and 2020 COVID-19) and gender group (females and males). The dependent variable was SMLSD fourth grade students' MAP Mathematics RIT average composite scores. When assessing multiple group comparisons, conducting a single two-way ANOVA test for any interaction effect between cohort and gender and controls for Type I error rate inflation is appropriate (Mertler & Vannatta, 2017).

Results

RQ1: SMLSD Fourth Grade Students' MAP Scores Compared to the National Norm

Table 1 reports descriptive statistics for SMLSD fourth grade students' MAP Mathematics RIT average composite scores by cohort.

Table 1

SMLSD Fourth Grade Students' MAP Mathematics Average RIT Scores (N=113) by Cohort

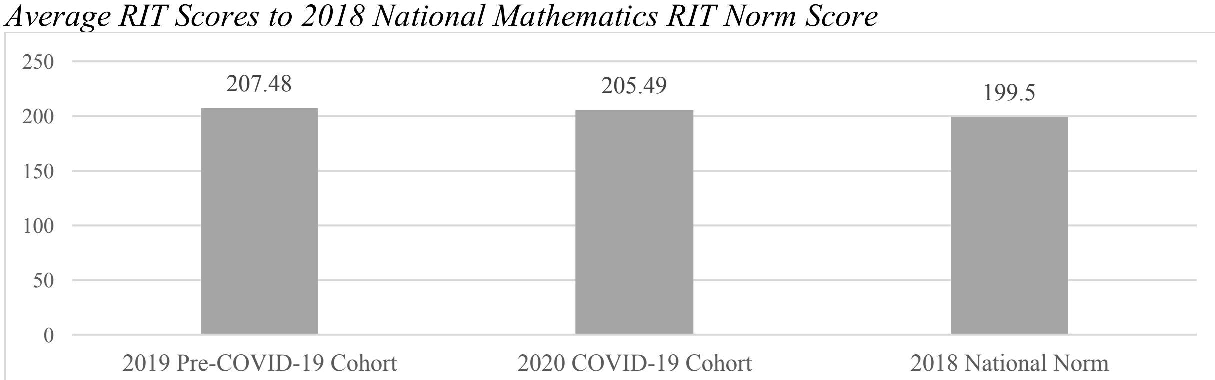
Variable	*n*	%	*M*	*SD*	*Skew*	*Z-value*
Cohort						
2019 pre-COVID-19	31	27.4	207.48	11.30	–1.95	–4.47***
2020 COVID-19	82	72.5	205.49	10.96	–0.28	–7.00***
Overall	113	100	206.04	11.04	–0.72	

Note. *** $p < .001$

SMLSD fourth grade students' scores for both cohorts were slightly negatively skewed but within the acceptable range of -2 and 2 (Hair et al., 2010). Figure 1 shows how the 2019 pre-COVID-19 and 2020 COVID-19 cohorts' MAP Mathematics average RIT scores compared to the national norm.

Figure 1

Comparison of 2019 Pre-COVID-19 Cohort and 2020 COVID-19 Cohorts' MAP Mathematics Average RIT Scores to 2018 National Mathematics RIT Norm Score



The 2019 pre-COVID-19 cohort's (M = 207.48) MAP Mathematics average RIT score was 7.93 RTI units higher than the 2018 national norm score (μ = 199.55, SD = 14.40). As reported in Table 1, the One-Sample Z-test showed the 2019 pre-COVID-19 cohort's MAP Mathematics average RIT score was statistically significantly higher than the 2018 national normal score, Z = –4.47, $p < .001$. Similarly, the 2020 COVID-19 cohort (M = 205.49) MAP Mathematics average RIT scores were 5.94 higher than the 2018 national norm score (μ = 199.55, SD = 14.40). The One-Sample Z-test also showed the 2020 COVID-19 cohort's MAP Mathematics average RIT score was statistically significantly higher than the 2018 national norm, Z = 7.00, $p < .001$. Both the 2019 and 2020 COVID-19 cohorts' average scores were within one standard half deviation of the national norm (see Figure 1).

RQ2: Interaction Effect Between Cohort and Gender on MAP Mathematics Scores

The two-way ANOVA tested whether there was a statistically significant interaction between cohort (2019 pre-COVID-19 and 2020 COVID-19) and gender (females and males) on SMLSD fourth grade students' MAP mathematics RIT average composite scores. Table 2 shows the gendered breakdown of the 2019 pre-COVID-19 cohort and 2020 COVID-19 cohort.

Table 2
SMLSD Fourth Grade 2019 pre-COVID-19 Cohort and 2020 COVID-19 Cohort MAP Mathematics Average RIT Scores by Gender

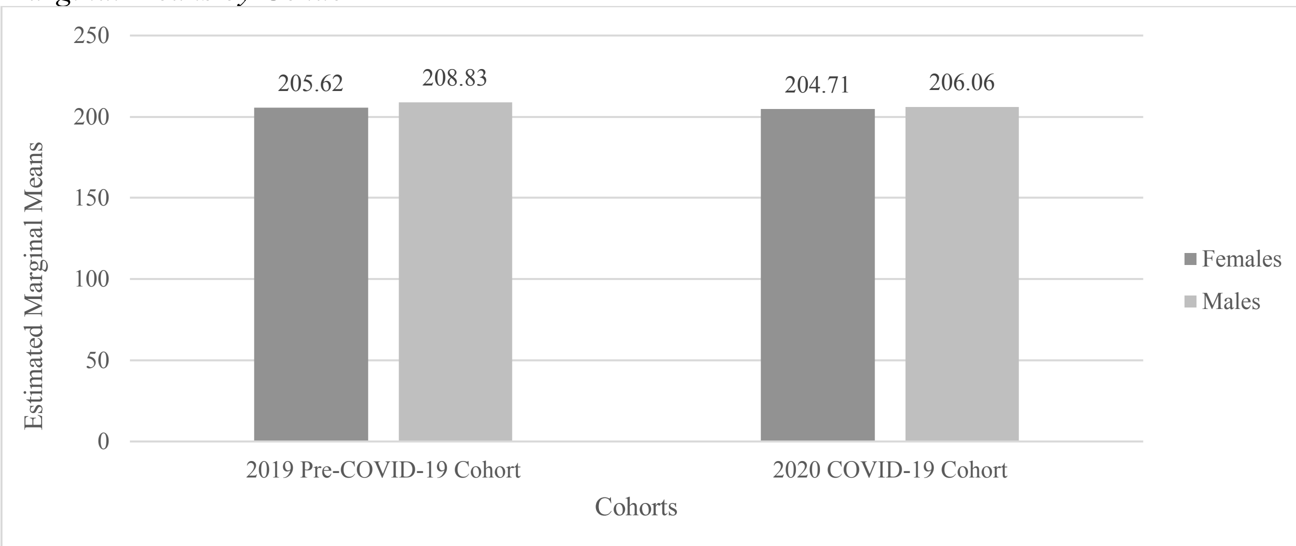
	Females					Males				
Cohort	*n*	%	*M*	*SD*	*Skew*	*n*	%	*M*	*SD*	*Skew*
2019 Pre-COVID-19	13	42	205.62	11.89	–1.38	18	58	208.83	10.99	–2.08
2020 COVID-19	35	43	204.71	9.25	–0.08	47	57	206.06	12.15	–0.42
Overall	48	42	204.95	8.89	–0.55	65	58	206.83	11.81	–0.87

Within both cohorts, there were a lower number of female fourth grade students than males resulting in an unbalanced design in regard to gender distribution. In the 2019 pre-COVID-19 cohort, females' and males' MAP Mathematics RIT average composite scores were slightly negatively skewed. The skewness values were within the acceptable range of -2 and 2 (Hair et al., 2010). In the 2020 COVID-19 cohort, female and males' MAP Mathematics RIT average composite scores were approximately normally distributed. Therefore, the two-way ANOVA assumption of normally distribution was met.

No statistically significant interaction effect was found between cohort (2019 pre-COVID-19 and 2020 COVID-19) and gender on SMLSD fourth grade students' MAP mathematics RIT average composite scores, $F_{(1, 109)} = .155$, $p = .694$, $\eta^2 = .001$. The estimated marginal means plot for the cohorts by gender group is illustrated in Figure 1. Figure 1 shows that the estimated marginal means for the two cohorts across SMLD fourth grade female and male students were similar. SMLD fourth grade females' MAP Mathematics RIT average composite score was 3.21 RTI units lower than males in the 2019 pre-COVID-19 cohort and 1.36 RTI units lower than males in the 2020 COVID-19 cohort.

Given that the interaction term was not statistically significant, the two main effects for cohort and gender group were tested. The two-way ANOVA showed no statistically significant main effect for cohort, $F_{(1, 109)} = .599$, $p = .441$, $\eta^2 = .005$. As shown in Figure 2, fourth grade students' MAP mathematics RIT average composite scores were similar for the 2019 pre-COVID-19 cohort ($M = 207.4$, $SD = 11.3$) and 2020 COVID-19 cohort ($M = 205.5$, $SD = 10.9$), regardless of gender group. Also, there was no statistically significant main effect for gender,

Figure 2
SMLD Fourth Grade 2019 pre-COVID-19 Cohort and 2020 COVID-19 Cohort Estimated Marginal Means by Gender



regardless of cohort, $F_{(1, 109)} = .927$, $p = .338$, $\eta^2 = .008$. Female ($M = 206.8$, $SD = 11.8$) and male ($M = 204.9$, $SD = 9.9$) SMLD fourth grade students' MAP mathematics RIT average composite scores among SMLSD fourth grade students differed by less than 2 RTI units.

Discussion

COVID-19 Disruptions on Mathematics Instruction and Performance

While only a single rural school was considered for this study, the impact of the COVID-19 pandemic may not have the lasting effects on all students that were initially thought. While conditions of test pollution could exist for some students, this study indicates that those not virtual for the entirety of the 2020-2021 school year did not have a statistically significant drop-off in mathematics test scores compared to students in the prior year. Furthermore, this study supports previous research on students having similar long-term outcomes in face-to-face and online mathematics instruction (Edwards et al., 2017). This study contributes to the academic discourse on mathematics performance, and differential effects in rural districts, by illustrating that virtual environments may not negatively influence mathematics knowledge retention for elementary-aged children. Moreover, as COVID-19 pandemic mediated classroom size, with students split between in-person and virtual learning, this rural socioeconomically advantaged school district may have benefitted from offering varying learning modalities. However, further research is warranted to comprehensively understand mathematics knowledge retention in various contexts and learning modalities.

Gender and Locality Considerations on Mathematics Performance

As it relates to demographic characteristics, specifically gender and rural locality, this study adds important nuance to the conversation. The research on gender differences in elementary mathematics education suggests that context matters and offers the most insights into student outcomes. For example, some literature suggests that there is often a male-favoring gender gap in mathematics assessments in socioeconomically advantaged communities (Reardon, 2018; Reardon et al., 2019; White et al., 2016). More research is needed to examine the intersection of gender and locality, specifically gender equity in rural elementary mathematics classrooms. Still, this study shows that wealthier rural schools with smaller classrooms may be better at mitigating gender bias. This result is in direct contrast to prior research (Reardon, 2018; Reardon et al., 2019), suggesting male-favoring advantages persist in socioeconomically advantaged school districts. Since these prior studies did not disaggregate their findings by locality, perhaps, the key nuance is *locality*. Other studies concur that these gender differences are very context specific (Hopcroft & Martin, 2016; Lubienski et al., 2013). Since there were no statistically significant differences based on gender groups between cohorts, there are likely other more salient factors that encourage gender equity in mathematics assessments and performance, such as familial investment, teacher encouragement, and resource equality (Yosso, 2005).

Social Capital and Rural Students' Outcomes

Although this study did not yield statistically significant differences among the pre-COVID-19 and COVID-19 groups, the social capital that this school district possesses (Israel & Beaulieu, 2004; Smith et al., 1995; Yosso, 2005) does aid in our understanding of the MAP mathematics RIT average composite scores. Based on these two cohorts to date in Spruce Mountain, there were no significant differences in mathematics performance. This finding offers evidence that supports the notion that mathematical performance did not decrease on the MAP Mathematics RIT due to COVID-19 related learning disruption in this school district. Furthermore, during the pandemic, the classroom sizes were somewhat smaller than pre-pandemic and possibly translated into improved academic performance compared to the 2020 national average. This hypothesis is supported by the literature showing that smaller class sizes make a positive difference in learning (Arias & Walker, 2004; Beattie & Thiele, 2016; Bowne et al., 2017).

Moreover, these students remain on par with the national average MAP mathematics fourth grade test scores across both cohorts (NWEA, 2020). As previously stated, this midwestern rural school district possessed ample resources and technology tools to support student learning with a median household income of $68,886. As a result, this school likely has "well-articulated norms and values that encourage good academic performance and limit problem behaviors" (Israel & Beaulieu, 2004, p. 264).

Scholars have posited school social capital as a salient factor in student success as school social capital focuses on the active engagement of educators and families in students learning (Nelson, 2016). For the SMLSD school district, the administration indicated that students attending in-person classes could receive greater attention from teachers. Elementary teachers would create small group instruction and remove their masks to enunciate when teaching children letters, sounds, and reading to allow students to see mouth formation. As previously noted, some teachers implemented differentiated instruction where their students had individual Zoom times.

Some adjusted their day to provide instructional support in the evenings to help parents. Some utilized the digital resources available in our district-adopted curriculum, and some implemented additional technology-driven resources. The school social capital that appeared in this district study school district provides a counternarrative to the deficit framing that the literature traditionally perpetuates about rural districts.

Conclusion and Areas for Future Research

This paper establishes a more nuanced understanding of elementary mathematics learning in a rural Midwest context. In doing so, it offers the opportunity for future researchers to consider the importance of asset-based framing and contextual factors in mathematics performance. Furthermore, an impertinent implication of the study's results for scholars is to consider within-context conditions of rural school districts across the United States to develop a more comprehensive understanding of the student mathematic learning and performance. Finally, Results from this study should be considered for future research studies and educators in mathematics classrooms that were impacted by the COVID-19 pandemic.

Three limitations to this study are noteworthy. First, only one Midwestern rural school district participated, which may affect the generalizability of the findings. Second, the 2019 pre-COVID-19 and 2020 COVID-19 cohorts were not matched samples limiting the inferences that can be drawn regarding the cohort effect. Third, only one measure of mathematical performance was used, providing limited knowledge of the influence of COVID-19 as a learning disruption. The results found in this study raise questions as to what factors might explain how the school district managed to maintain its fourth grade mathematics performance to be close to the national average during an educational emergency (COVID-19), or what educational policy and instructional methods were implemented in the schools to keep the gender gaps in mathematics achievement low. These questions may call for complementary data sources (e.g., teacher interviews, document analysis, observations) beyond standardized test scores.

Going forward, educators and researchers should not assume that the COVID-19 pandemic inherently caused a negative impact on mathematics student learning in rural school settings based *solely* on the move to virtual learning. Other well-funded technology and wealthy schools in suburban or urban settings could see similar results as this study. Still, additional research studying mathematic performance within the rural context is needed. Additionally, the results of this study could extend to mathematics state standardized tests and should be further investigated. However, as the students in this study were mostly white, more diverse student populations in various rural settings should be explored to determine statistically significant differences in mathematics scores between students of varying backgrounds. Future studies could explore the prediction that Latinx and Black students are more likely to fall behind their peers, particularly in rural contexts (Seiden, 2020).

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Institutional Review Board (IRB) approval was obtained for this study.

Ideas in this work stem from multiple grant-funded research studies supported by the National Science Foundation (NSF# Blinded for peer review). Any opinions, findings, conclusions, or recommendations expressed by the authors do not necessarily reflect the views of the National Science Foundation.

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