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An Exploration of Elementary Mathematical Performance during the COVID-19 Pandemic

Rachel Sunshine Herron

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AN EXPLORATION OF ELEMENTARY MATHEMATICAL PERFORMANCE DURING THE COVID-19 PANDEMIC, a Doctoral research project prepared by RACHEL SUNSHINE HERRON in partial fulfillment of the requirements for the Doctor of Education degree in Educational Leadership.

This dissertation has been approved and accepted by:

		Committee Chair
July 2, 2022	Karen Buchanan, Ed.D.	Professor of Education
July 2, 2022	Gary Sehorn, Ed.D.	Associate Professor of Education
July 2, 2022	Greg Aldred, Ed.D.	Adjunct Professor of Education

Abstract

School disruptions impacted public schools in Oregon for fifteen months. As a result, mathematical performance may have been impacted. School districts, educational leaders, and policymakers need information on how and to what extent disruptions to in-person learning have affected student mathematical performance. This was a non-experimental, post-hoc quantitative causal-comparative study. Existing i-Ready data was used to explore if there was evidence of significant differences in mathematical performance within and between gender and ethnicity-based groups of fifth-grade students as a result of the pandemic. The results of this study revealed that differences in students' mathematical performance did change during the pandemic, and it may have been related to school closures. Latina, Latino, white female, and white male students experienced statistical and practical differences in mathematical performance during school disruptions. However, this study revealed that, in isolation, neither gender nor ethnicity seemed to shape students' mathematical achievement; Latino male and white female students experienced higher-than-expected growth, whereas Latina and white male students experienced lower-than-expected growth. Understanding how mathematical performance changed during the pandemic at the intersectionality of gender and ethnicity can support the national calls to provide an equitable education to all students. School leaders can benefit by fostering conversations about equity, and understanding the mathematical trends of sub-groups of students could limit the likelihood of tracking students into low-level math groups and support excellence for all students. Teachers can foster equity in the classroom by supporting student agency, capacity, and belonging. Teachers should also teach grade-level content to all students while promoting accelerated learning pathways for all students as a way to ensure students are not tracked and placed into lower-level math classes.

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The path that has been paved for me, is one that I am not in charge of. I will follow His guidance, wherever that may take me. Life is always beautiful when you know how fragile it is.

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Chapter One: Introduction

School districts across America were abruptly shut down in the spring of 2020 due to the COVID-19 pandemic, causing a significant disruption to education systems as districts scrambled to convert to remote instruction. Many public-school districts shifted from on-site to home-based instruction during the 2019-2020 school year (Gross et al., 2020), including public school districts in Oregon, where the pandemic disrupted in-person public education for fifteen months (Oregon Department of Education & Oregon Health Authority, 2021).

For Oak Water School District (OWSD) (pseudonym), a rural school district in Oregon, the 2019-2020 school year started like every other year. The mathematical practices in schools were exciting and engaging; students shared their thinking as they collaborated with partners to justify their answers. Partners would frequently end up with the same solution, sometimes not. Either way, teachers engaged students with exciting learning opportunities through discourse, partnerships, and engaging math activities. Teachers intentionally provided scaffolds for groups of students who needed extra support to ensure each student experienced appropriate productive struggle. As the school year progressed, students received focused mathematics instruction and other services, such as speech and language development, special education services, enrichment, and supplemental instruction. Primarily, students had collaborative partnerships every day with their peers.

On March 12, 2020, teachers and students ended the day with a happy “have a good weekend, I’ll see you Monday” as they left for a three-day weekend. Nobody knew it at the time, but this was the last time students would attend school inside the buildings of OWSD for seven months. The next day, the Governor of Oregon announced statewide K-12 school closures for two weeks (Office of the Governor State of Oregon, 2021). Five days later, the state-mandated

school closures were extended through the end of April for all students (Office of the Governor State of Oregon, 2020a). Teachers and staff returned to empty buildings at the beginning of April to mobilize an unprecedented distance learning endeavor. School buses transported materials, manipulatives, technology, and school supplies to families instead of transporting students. School leaders gathered Chromebooks and hotspots to provide each student access to their education. By the end of April, the state-mandated school closures were officially extended through the end of the school year (Office of the Governor State of Oregon, 2020b). All teachers, staff, and administrators did their best to support students during these challenging times.

Throughout the pandemic, educational leaders called for public school districts across America to maintain grade-level academic rigor while capitalizing on opportunities to address unfinished and interrupted learning (Council of the Great City Schools [CGCS], 2020; National Council of Teachers of Mathematics [NCTM], 2020; Oregon Department of Education, 2020a). This task was especially challenging for schools in rural districts like OWSD because they typically have less access to technology, resources (Lavalley, 2018; Redding & Walberg, 2012), and quality professional development (Lavalley, 2018). As small rural school districts developed instructional plans during the pandemic, they were more likely to work in isolation with limited resources, making it more challenging to adjust to the changes necessitated by the pandemic than their urbanized counterparts. Additionally, since rural communities are more likely to experience deep and persistent poverty (Lavalley, 2018), maintaining high levels of academic achievement in mathematics was challenging (Hirn et al., 2017) even before these extended disruptions to in-person learning.

Researchers and educational leaders predicted students would experience extensive amounts of unfinished learning in mathematics because of these disruptions (Allensworth et al.,

2000; CGCS, 2020; Kaden, 2020; NCTM, 2020; Oregon Department of Education [ODE], 2021). Research exploring whether these predictions are accurate is timely and vital; students in rural schools may be in particular danger of mathematics learning loss based on the typical challenges their districts experience. COVID-19 and resulting disruptions to in-person learning have created a unique moment in time to study whether and to what extent these challenges have shaped students' mathematical performance. This study explored these connections within a rural district, with a particular focus on whether the pandemic exacerbated mathematical performance differences between groups where existing disparities in academic performance have already been identified: namely gender and ethnicity. Since research indicates mathematical performance can differ within and between these groups (Davis-Kean & Jager, 2014; Lee, 2002), it is important to learn whether these differences widened during the pandemic.

Mathematical Performance and Ethnicity

A more comprehensive discussion of the literature around the connections between mathematical performance, gender, and ethnicity is explored in Chapter 2. However, it is essential to note that longitudinal studies have found the most considerable rate of growth in mathematics among all students in kindergarten through high school occurs between the ages of 5-10 (Davis-Kean & Jager, 2014, Kuhfeld et al., 2018; Lee, 2010). These growth rates slow by the age of twelve (Davis-Kean & Jager, 2014; Kuhfeld et al., 2018), when the gap between the lowest-performing white students and the highest performing Latino/a students begins to widen (Davis-Kean & Jager, 2014). Such learning trends are also evident in other educational systems, such as Hong Kong (Mok et al., 2015). This research highlights a need for further investigation into why and how such disparities exist, as well as how pandemic-induced disruptions to in-person learning have affected them. While it is evident that all students whose learning was

interrupted during their most formative learning years missed meaningful opportunities for in-person interventions, connections, and discourse with peers and strong teachers, it is essential to understand whether and to what extent mathematical performance has changed within ethnic and gender-based subgroups during these disruptions.

Mathematical Performance and Gender

Decades of research studies have sought to establish and quantify whether gender-based differences in mathematics exist; research indicates male and female students' mathematical performance is more similar than different (Else-Quest et al., 2010; Hyde, 2014; Li et al., 2017; Lindberg et al., 2010; Reilly et al., 2015). In an international meta-analysis, Else-Quest et al. (2010) explored mathematical performance data using the Trends in Mathematics and Science Study (TIMSS). Forty-six countries were part of their study, with only two countries (Bahrain and Jordan) that had nearly medium effect sizes favoring females -0.42 and -0.30, respectively. The remaining forty-four countries showed negligible or virtually zero effect sizes between male and female mathematical performance, suggesting almost no difference in mathematical performance between gender groups.

Similarly, Lindberg et al. (2010) and Else-Quest et al. (2010) reported negligent effect sizes in the United States between math performance scores for males vs. females since 1990 and 1983, respectively. Yet despite consistent negligent effect sizes between male and female mathematical performance, women continue to be underrepresented in STEM and engineering careers (Else-Quest et al., 2010; Hyde et al., 2008; Hyde, 2014; Li et al., 2017; Mozahem, 2021; Reilly et al., 2015), leading researchers to continue researching the disparities between male and female mathematical performance.

Many studies have parsed data to identify and pinpoint gender differences in mathematics performance (Else-Quest et al., 2010; Hyde et al., 2008; Hyde, 2014; Lindberg et al., 2010; Li et al., 2017; McGraw et al., 2006; Mozahem, 2021; Parker et al., 2019; Reilly et al., 2015). These studies have shed light on a small gap between male and female math performance over the past three decades, and a more significant career gap in engineering and STEM professions. While these studies have contributed a vast amount of knowledge, research has consistently focused on disparities, achievement gaps, and identifying how females and different ethnic groups can reach parity with white males.

Purpose of this Study

This study used i-Ready, which is a computer adaptive mathematics assessment (Curriculum Associates, 2021) used at the elementary level at OWSD to examine mathematical performance for groups disaggregated by gender and ethnicity and make within-group comparisons. This study can help educators understand students' mathematical performance trends during the pandemic; it can also attend to the calls for the critical work still needed for educators to provide an equitable education for all students. It does this by shifting the narrative around achievement gaps from one of helping everyone achieve parity to one that embraces and fosters equity for each group of students, based on their needs. Focusing on gender alone is likely to provide an incomplete picture of how students perform in mathematics (Campbell, 1989; McGraw et al., 2006); instead, researchers have identified a need to research the intersectionality of social constructs, such as gender and ethnicity together (Campbell, 1989; Leyva, 2017; Parker et al., 2019). Examining mathematical performance through an intersectionality lens of gender and ethnicity provided teachers, educational leaders, and policymakers insights into how

mathematical performance trends changed during the pandemic for groups of students who are historically underserved, underrepresented, or otherwise overlooked in the research.

The purpose of this study was to discover if there was evidence of significant differences in mathematical performance within and between gender and ethnicity-based groups of students both before and during the pandemic. I used a quantitative research design and existing data to ascertain whether significant differences in mathematics scores were evident in a group of students who attended third and fifth grades before the pandemic. I then compared this analysis to students who attended third grade before the pandemic and fifth grade during the pandemic. Specifically, this study examined whether these differences were observable in sub-groups distinguished by the intersectionality of students' gender and ethnicity.

Research Questions

1) Did the mathematical performance change in a rural Oregon school district between a group of students who were not impacted by school disruptions and a group of students who were impacted by school disruptions due to the global pandemic as measured by i-Ready scores?
2) Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latina and white female students as measured by i-Ready scores?
3) Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latino male and white male students as measured by i-Ready scores?

Significance

Researchers have suggested gender studies need to expand beyond the scope of differences in male and female performance in mathematics and look at the nuances within sub-groups of students (Gutiérrez, 2008; Hyde, 2014; Leyva, 2017; Lubienski, 2008; McGraw et al., 2006; Parker et al., 2019). For instance, Gutiérrez (2008), Leyva (2017), and McGraw et al. (2006) all suggested a shift to studying within-group differences instead of only focusing on between-group differences. Accordingly, this study sought to use the i-Ready assessment tool to do that work. This study also contributed valuable information to school leaders in the rural district where this study took place, in terms of identifying potential areas of improvement and support. School districts, educational leaders, and policymakers need information on how and to what extent disruptions to in-person learning have affected student performance.

Definition of Terms

Rural areas are classified as non-urban, comprised of open country and settlements with fewer than 2,500 residents, and have less than 500 people per square mile. Rural areas can be categorized as: completely rural, mostly rural (OWSD falls into this category), or mostly urban (Ratcliffe et al., 2016).

Math performance is a measurement based on a demonstration of skills mastery (Collins & O-Brien, 2011); in this study, math performance was measured by the i-Ready assessment.

Common Core State Standards is a tool for teachers to identify what mathematical skills students should be proficient in at each grade-level (Oregon Department of Education [ODE], 2011).

Ethnicity is a social group consisting of people who share common national or cultural traditions (Collins & O'Brien, 2011; Stevenson & Lindeberg, 2010).

Gender is a social construct typically described as the binary male and female (Collins & O'Brien, 2011; Stevenson & Lindeberg, 2010).

i-Ready is a computer adaptive mathematics assessment measuring academic performance based on a vertical scale score ranging from 100 to 800 (Curriculum Associates, 2021).

Curriculum-Based Measurements (CBMs) are the most common form of assessment teachers use to measure students' mathematical performance within an academic year (Ball & Christ, 2012; VanDerHeyden et al., 2017).

Study Design and Researcher Identity

I chose this study design because I am concerned with understanding the degree to which pandemic disruptions have affected students' mathematical performance. I have a deep passion for researching students' mathematical performance, specifically when it comes to meeting instructional needs for historically underserved student populations. My study design provided a snapshot of what learning disruptions have meant for a particular area of academic performance, supporting discussions of how the pandemic may be affecting learning trends.

I have worked at OWSD for the past five years and am currently the Assessment & Data Coach for the district, making it a convenient location to conduct this research study. Additionally, over the past five years, administration, teachers, specialists, and coaching staff have prioritized data-informed instruction, grade-level and school-wide collaboration, and district-wide consistency related to mathematics instruction and assessment. Each of these endeavors limits the degree to which these factors are confounding variables in this study. As OWSD has built and maintained these consistent systems and structures for the past five years, the i-Ready assessment system has provided baseline data to inform intentional instructional groups and accelerated learning for all students. OWSD has also used the i-Ready diagnostic to

analyze each student's yearly growth progress and teachers use it to identify next steps for instruction.

The research questions for this study stemmed from my recognition of the need for more research in mathematical performance trends focusing on the intersectionality of gender and ethnicity. Understanding whether and to what extent the mathematical performance between these variables changed during the pandemic has implications not only for how our district might respond but may offer helpful insight for further research. It is critical to extend future research beyond ethnicity and gender-based conceptions of performance to examine the intersectionality of factors represented within math achievement scores.

Limitations of Study

There are three limitations to this study. I compared i-Ready mathematic scale scores before and during the pandemic. The data analysis provided pertinent insights into whether significant differences in scores and their magnitude before and during a significant disruption to learning. However, analyzing performance scores did not enable a judgment on how or why any discovered differences existed. Additionally, the results of this study were not able to inform instructional adjustments or further explain the academic needs represented.

Finally, this study was limited to studying data from a single school district in a rural community, which only provided information about this district without being generalizable to other districts, rural or otherwise. Nevertheless, this study was still useful in identifying trends and patterns within the scope of mathematical performance related to variables of ethnicity and gender, contributing to the growing body of knowledge surrounding the pandemic and its effect on mathematical performance.

Delimitations of Study

There are a few delimitations to this study. First, I intentionally chose this convenience sample based on the willingness of the administrators and school district to participate; this makes the study feasible and supportive to the on-the-ground needs of a school district. I also used winter i-Ready diagnostic data instead of fall and spring. The last data point for the 2019-2020 school year was the winter i-Ready diagnostic assessment because the school district did not administer the spring assessment due to the pandemic. I have chosen not to include the fall 2020 diagnostic because there was so little time for teaching and learning.

Finally, due to the inconsistencies in student participation and environmental differences, I did not include any i-Ready data from the 2020-2021 school year. Some students took the assessment at home, and others took it at school, creating discrepancies in the reliability and validity of those scores.

Organization of Study

The organization of this research study consists of five chapters. In this first chapter, I have introduced the study, providing pertinent background to the problem of practice, the rationale, and research questions. Chapter Two offers an extensive literature review discussing how mathematical performance is conceptualized in educational research, focusing on ethnicity and gender. Chapter Three discusses my methodological framework, data collection, and analysis techniques.

Throughout the global pandemic, school districts experienced unprecedented interruptions to regular in-person education. Educational leaders have predicted that students would experience substantial amounts of unfinished learning in mathematics, potentially exacerbating existing disparities. This study analyzed the mathematical performance of fifth-

grade students during the pandemic, specifically at the intersectionality of gender and ethnicity, to understand whether and to what extent these learning disruptions are reflected in mathematical performance data.

Chapter Two: Literature Review

This literature review describes the current research regarding children's mathematical performance and how it has been studied, defined, and operationalized within other research studies. Mathematical performance tests and measurements are explained, along with the validity and reliability considerations within those measurements. This chapter moves into an exploration of mathematical performance and gender, based on Hyde's (2005) research, which is foundational in gender studies research. The chapter also discusses research on whether gender-based and ethnicity-based differences exist in early mathematical performance while discussing the achievement gap concerning mathematical performance and ethnicity, namely between Latino/a and white students. A discussion about mathematical performance and its intersectionality with gender and ethnicity constructs is also relevant, drawing on the intersectionality research of Crenshaw (1991) and McCall (2005). This literature review concludes with what the field presently understands about disruptions to learning such as natural disasters or pandemics, and how these shape students' mathematical performance.

Literature for this review was found through EBSCOhost search engines, with a focus on keywords such as "pandemic learning disruptions" and "mathematical performance." Seminal research articles were derived from reference lists. All articles included in this review were peer-reviewed research from the past twenty to thirty years, to gain insights into modern-day trends around mathematical performance.

Mathematical Performance

Mathematical achievement is typically measured by summative, end-of-year, or unit-based assessments (Collins & O'Brien, 2011). Achievement indicators often include state tests, which are administered on an annual basis. These data are reported to Trends in International

Mathematics and Science Study (TIMSS), Programme for International Student Assessment (PISA), National Assessment of Educational Progress (NAEP), or other data collection systems, revealing big-picture trends and patterns over time. It is also important to measure students' mathematical performance and progress on a more regular basis; this is typically done more informally through school site or district assessments. Performance measures can help identify district, school, or classroom performance trends and growth over time. This section of the literature review includes an exploration of how such measurements came about, along with how performance measures have been studied, operationalized, and used to track learning patterns at more local levels. This discussion establishes appropriate measurements for analyzing district trends for mathematical performance in this study.

Dating back to the early 1900s, Alfredo Binet was the first to explore adaptive assessments in his work on the development of intelligence tests. Binet sought to pinpoint ability levels by rank ordering items by level of difficulty, thereby enabling him to tailor tests to ascertain an individual's strengths. His work enabled researchers to see how to create a subset of items that progressively became more difficult or switched to easier questions, depending on a test-taker's performance (Deno, 2003; Linacre, 2000). Researchers who further expanded and refined Binet's work include Deno (2003) who established curriculum-based measurements (CBMs), which are assessments teachers use to measure students' mathematical performance within an academic year (Ball & Christ, 2012; VanDerHeyden et al., 2017) and Fuchs (2004) who expanded the use of CBMs to screen students for academic risk factors and progress monitor students' growth between multiple points in time.

Mathematical Performance and Child Development

The Oregon Department of Education (2011) created The Common Core State Standards as a tool for teachers to identify what mathematical skills students should be proficient in at each grade-level. The standards were designed in such a way that students can systematically learn mathematical concepts within and across each grade level. Measures of mathematical performance in early childhood suggest the importance of play for helping children develop spatial skills (Rittle-Johnson et al., 2019), learn how to count (Claessens & Engel, 2013), and construct patterns (Claessens & Engel, 2013; Fyfe et al., 2017); these skills are all critical to students' long-term success in mathematics. These primary skills also function as building blocks for numerical development from birth through adolescence (Clements & Sarama, 2014; Siegler et al., 2011) and in the acquisition of numerical magnitudes, pertaining to both whole numbers and fractions (Siegler et al., 2011). It is important to further note that fraction proficiency has been widely recognized as a predictor of algebra success (Booth & Newton, 2012; Hansen et al., 2017; Jordan et al., 2013; Siegler et al., 2011). Mathematical skills build across the grade levels, but it is equally important that students have opportunities to engage in learning.

Rittle-Johnson (2019) described learning mathematics as an iterative process; students move back and forth between conceptual development to procedural skills and spiral back to skills that have been taught but not mastered yet. Additionally, children do not develop mathematical skills in isolation but through scaffolded instruction within each student's instructional level (Anderman et al., 2014; Sweller, 1994; Walshaw, 2017). This is especially important in the elementary years because children grow in their mathematical abilities the fastest in their elementary school years compared to middle and high school (Davis-Kean &

Jager, 2014; Kuhfeld et at., 2018; Lee, 2010; Reardon & Galindo, 2009). Taken together, children can naturally develop mathematical skills through play but will need support to develop systematic processes that include logical and abstract thinking. Skilled teachers shape these learning moments over time, based on where students are developmentally. Students who experience disruptions in learning could miss important learning opportunities necessary to develop more advanced mathematical concepts that were taught in earlier grade bands, requiring the iterative process of conceptual and procedural skill development and appropriately scaffolded instruction.

Measuring Mathematical Achievement

Measuring mathematical achievement became increasingly important to do in the wake of the No Child Left Behind (NCLB) era. As a result of this major policy change, districts across the country implemented new ways of measuring students' mathematical achievement. Policymakers shifted toward high stakes testing and began to hold districts accountable for providing an equitable education to all students (Murray, 2014). The federal government judged all public-school districts by their achievement levels on yearly high-stakes tests and used these tests as measures by which to determine whether to withhold federal funding or employ sanctions on low-achieving schools (US Department of Education & Office of Elementary and Secondary Education, 2002). To better understand mathematical performance, educational leaders shifted to measuring and monitoring the progress of all students. While measuring student performance was not a new idea in education, high stakes testing, and the subsequent accountability measures nudged school districts to take a stronger interest in utilizing performance data.

Mathematical achievement gets established and revisited through national and international standards (National Assessment of Educational Progress [NAEP] 2022; Programme for International Student Assessment, 2022; National Center for Education Statistics, 2022) and measured by what is often termed high-stakes tests. Benefits to high-stakes testing include the possibility of informing educational policy with data, the ability to evaluate student achievement both from a national and international standpoint, and the ability to track trends in mathematical achievement (Anderman et al., 2014). These benefits enable researchers to determine achievement gap trends and identify differences and similarities between and within groups.

There are also drawbacks to using high stakes testing as a means of identifying students' mathematical performance. These tests are also typically administered annually, and so are not able to reflect growth measurements for students within an academic year. For instance, state assessments measure students' mathematical achievement once a year and categorize students by their proficiency levels, such as below basic, basic, proficient, and advanced (NAEP, 2019; ODE, 2021). While this provides information about group similarities and differences, it cannot account for student growth across categories on a regular basis.

While education needs to identify norms and standards related to student achievement, this large-scale and annual approach does not provide meaningful data at local and state levels. As a result of high stakes testing and tightened accountability measures, school districts have implemented additional mathematical performance measurements to gauge student performance in less formal ways and track student growth within an academic year.

Measuring mathematical performance with curriculum-based measurements. CBMs, developed by Deno and Mirkin in the late 1970s, are the most common form of assessment teachers use to measure students' mathematical performance within an academic year

(Ball & Christ, 2012; VanDerHeyden et al., 2017). The initial purpose of CBMs was to screen students for academic risk factors and measure interventions in special education, enabling teachers to monitor the progress of students reintegrating into general education classrooms (Deno, 1985; Fuchs, 2004). By the 1990s, and particularly with NCLB policies, CBMs shifted to a broader range of utilization and functionality, and general education teachers began to use them to monitor all students' performance (Stecker et al., 2005). Fuchs (2004) outlined two key ways CBM measurements can be used.

The first approach, curriculum sampling, is a CBM in alignment with the curriculum children learn each year. These assessments are easy to implement because of their single skill focus (VanDerHeyden et al., 2017). Deno’s (2003) research suggested that the standardization in administration and scoring of these measurements would ensure more reliable and valid results that could inform classroom instruction. This assertion was questioned in research by Ketterlin-Gellar & Yovanoff (2009), who indicated CBMs designed to measure student achievement of grade-level skills may not be as reliable as growth measures because they cannot account for whether or not students have the prerequisite skills they need to access grade-level content. However, Fuchs’ (2004) second approach for CBM use, also known as robust indicators, may address this issue. When CBMs are used as robust indicators, they measure the proficiency of a skill, which includes similar skills that could indicate the level of knowledge students have for a given skill (Lembke & Stecker, 2007). This could help identify correlated or aligned prerequisite skills students need to access grade-level mathematical content. This means CBMs with robust indicators could provide helpful insights into how student performance changes over time (Anderman et al., 2014) and across grade levels (Foegen et al., 2007). This is especially important for monitoring the academic growth of all students, regardless of their performance

levels. As researchers continue to study mathematical performance trends through the pandemic and identify potential differences in mathematical performance during school closures, it is important to utilize a measurement that includes robust indicators to show a complete understanding of growth amongst all students; not just those who are performing at grade-level.

Measuring mathematical performance with computer adaptive tests. Computer adaptive tests (CAT) are tools used to measure mathematical performance. They are typically developed using item response theory and the Rasch model to identify questions tailored to students' academic levels (Linacre, 2000; Smarter Balanced, 2021; Weiss, 2004) to find students' true ability levels. Two CAT measurements relevant to this discussion are the Smarter Balanced Assessment (SBA) and the i-Ready diagnostic assessment. While both assessments measure academic and mathematical performance, their purposes differ. The SBA measurement is given annually and used to categorize students by their achievement levels, whereas the i-Ready measurement is used to identify the proficiency levels of students to inform instructional practice and track growth over time.

Smarter Balanced Assessment. The Smarter Balanced Assessment is an annual assessment administered in thirteen states and the US Virgin Islands (Smarter Balanced, 2022). Its primary purpose is to measure academic and mathematical achievement levels to effect positive change within lower-performing schools where groups of students are not making adequate progress (U.S. Department of Education, 2017). While the SBA measurement is computer-adaptive, it is not a CBA because it does not monitor the progress of student achievement throughout the year or over time (Fuchs, 2004); it is given annually, in grades three through eight and eleven (ODE, 2021). The computer-adaptive technology used in the design of the SBA measurement is concerned with categorizing students into their mathematical

achievement levels, which is determined when students' true ability (theta) and their standard error fall below a predetermined cut score (Smarter Balanced, 2021; Stafford et al., 2018). In the case of the SBA measurement, students are identified within one of four levels, with levels three and four indicating students are proficient, or on track for college and career readiness. Likewise, students who are categorized in levels one and two are identified as at risk for not being on track for college and career readiness (Smarter Balanced, 2020). While the SBA mathematical measurement provides insights as to how students perform in mathematics by way of categorizing them into achievement levels, it does not tell at which levels students are performing. Put another way, the SBA measurement can help teachers identify whether students have mastered grade-level mathematics skills; it cannot measure or indicate prior knowledge for students who perform above or below grade level (Anderman et al., 2014; Linacre, 2000). Further, the SBA is given once annually, making this an inadequate indicator of students' progress within a particular academic year.

i-Ready. In contrast, the i-Ready diagnostic, developed by Curriculum Associates, in 2011, is both a CAT and a CBM with robust indicators connected to the Common Core State Standards. The i-Ready mathematics diagnostic is typically given three times a year and has been used as a screening measure to identify students who are potentially at risk for not meeting grade-level mathematical expectations. It efficiently measures student ability levels (Curriculum Associates, 2019a) as opposed to categorizing student achievement levels as the SBA does (SBA, 2021). This means that the SBA situates students into a categorical level of performance while the i-Ready measurement provides an actual ability level for each student.

Both the SBA and the i-Ready tests terminate once a student has answered a predetermined number of items; the i-Ready mathematics diagnostic provides a total of sixty-six

to seventy-two items between four mathematical domains: algebra and algebraic thinking, number and operations, geometry, and measurement and data (Curriculum Associates, 2019b). According to Stafford et al. (2018), twenty items are sufficient to identify a student's true ability (theta) level, which indicates i-Ready is collecting more than sufficient data to identify student ability. This type of measurement is commonly utilized in the classroom setting due to its ease of use, efficiency, and high correlation to the SBA and other high-stakes tests around the nation.

Growth measures such as the i-Ready diagnostic, which utilizes computer-adaptive technology with robust indicators can be especially helpful in understanding how students who perform within the outer limits of their grade level make progress over time, as well as monitoring students on target for grade-level proficiency. Anderman et al. (2014) claimed that "repeated administrations of an assessment across several years–as long as the scores from the assessment can be vertically scaled across academic years–can provide educators with information about rates of growth in learning (in addition to absolute learning)" (pg. 141). Computer adaptive tests such as the i-Ready mathematic diagnostic could provide a measurement that gauges this type of growth across grade levels and throughout different points in time.

In the next section of the literature review, the validity and reliability of the i-Ready diagnostic as a growth measurement and its correlation to the SBA is explored. This framework is derived from Fuchs' (2004) stages of research, which was developed for the purpose of identifying whether CBMs are valid and reliable.

i-Ready as a growth measure. Tirado & Shneyderman (2020) conducted research for Miami Dade Public Schools, using i-Ready diagnostic assessments to measure growth over a period of three years for students in kindergarten (2015-2016) to third grade (2018-2019). Their

study took an intersectional approach with multiple variables. The specific focus of the study was on the annual rate of academic growth and the average rate of summer academic growth or decline. The first group was comprised of Hispanic females who were receiving free and reduced lunch and were English language learners. The second group consisted of white females who were not receiving free and reduced lunch and were not English language learners. The results of this study revealed a twenty-six-point difference between the kindergarten-aged group of Hispanic females compared to kindergarten-aged white females. The gap still existed by the end of third grade, although it decreased by two points on average. Each year, the summer decline was nearly the same between the two groups. While the results of this study do not provide explicit next steps from an instructional perspective, it does reveal disparities in learning trends at the intersection of ethnicity and gender, requiring a closer look at potential gaps in instruction, programs, or learning opportunities for certain groups of students.

Validity and reliability of i-Ready. The i-Ready mathematics diagnostic measurement is highly correlated to yearly high-stakes tests (Curriculum Associates, 2022). Data collected between the 2017-2018 and 2020-2021 school years found a high correlation between the i-Ready mathematics diagnostic and yearly high stakes tests in twenty-eight states and the District of Columbia (Curriculum Associates, 2022). Specifically, a correlational study was conducted by Curriculum Associates (2022) using the spring i-Ready diagnostic scale score from grades three through eight alongside students' SBA state assessment scores. It revealed an average correlation of .89 between the two measurements. This study demonstrated how likely it is that a student performing well on the i-Ready mathematics diagnostic will also perform well on the SBA state assessment. A correlation of .70 is considered strong as reported by National Center on Intensive Intervention (2021). A correlation coefficient of 1.0 is a perfect correlation. Thus, a .89

correlation coefficient between i-Ready and SBA indicates a strong correlation between the two measurements.

In a recent study reported to National Center on Intensive Intervention (2021), the winter i-Ready mathematics diagnostic from the 2017-2018 school year, which included students from grades three through eight, was cross-validated using the criterion measure SBA. SBA's criterion to measure cut-points for identifying at-risk students was the 20th percentile; i-Ready used the same cut-point scores. The results were reported as having a high sensitivity (true positives), 0.81 in both third and fourth grades, and high specificity (true negatives), 0.87 and 0.88 in grades three and four, respectively, with a confidence interval of 0.95. A measurement is rated high when its sensitivity rate is 70% or higher with a specificity rate of at least 80% (NCII, 2021). This indicates the i-Ready mathematics diagnostic assessment had an 81% accuracy rate of true positives (students who were predicted to score above the 20th percentile on SBA scored that way). Likewise, the study revealed about an 87% accuracy rate of true negatives (students who were predicted to score below the 20th percentile on the SBA scored that way). Taken together, these results indicate school districts that utilize the i-Ready mathematics diagnostic measurement can identify student growth patterns over time and anticipate how likely students are to meet grade-level mathematical achievement as measured by the end-of-year SBA assessment. The data can also be disaggregated to identify gaps in learning between and within distinct groups of students, such as gender and ethnicity.

The next section of this literature review explores mathematical performance and its intersection with constructs of ethnicity and gender. It concludes with the latest research pertaining to mathematical performance and the ways the pandemic potentially impacted

students' performance to explain what is presently known about these topics and how they relate to this study.

Mathematical Performance and its Intersectionality with Constructs of Ethnicity & Gender

Intersectionality can be defined as a framework to analyze groups of people at the intersections of multiple marginalizations (Crenshaw, 1991). It is useful for helping researchers identify the ways learners' various challenges can be layered and interactive, offering new voice, insight, or action for those living in those intersections. At its conception, intersectionality was rooted in Black feminism and Critical Race Theory. Since its inception, it has become a fluid framework that can and should evolve, influencing political, justice, and education systems through the years (Crenshaw, 1991; Cho et al., 2013; Codiroli-Mcmaster & Cook, 2019; McCall, 2005). Intersectionality's focus has remained the same throughout the past thirty years: seeking to reveal how different powers emerge within and between groups of people at the intersections of social structures, such as ethnicity and gender.

Intersectionality in Education Research

Many educational researchers have indicated that studying the constructs of gender and ethnicity independent of each other is not helpful. Historically, studies have revealed disparities in mathematical performance between ethnicity and gender by comparing minority groups to white males, perpetuating society's perception of that group's power over underrepresented students (Codiroli-Mcmaster & Cook, 2019; Crenshaw, 1991; Gutiérrez, 2008; Hyde, 2005; McCall, 2005). Such research designs promote deficit thinking and unnecessarily problematize differences between students of different ethnicities and genders (Gutiérrez, 2008). Studying intersectionality from an educational perspective could shift the lens from an unnecessary effort to create parity between sub-groups of students to one that analyzes and understands

performance changes within student subgroups (Choo & Ferree, 2010; Codiroli-Mcmaster & Cook, 2019; McCall, 2005). A study of mathematical performance and the intersectionality of ethnicity and gender could provide insights into these constructs.

People experience advantages and disadvantages differently; intersectionality studies provide an opportunity to explore how students in each group performed. Codiroli-Mcmaster & Cook (2019) suggested that gender and ethnicity are two of the top three most researched and prevalent forms of inequalities in education, making them important categories to explore within a quantitative intersectional study. This study aimed to identify if and how mathematical performance changed during the pandemic at the intersection of gender and ethnicity.

Quantitative Research and Intersectionality

While intersectionality in quantitative research has become more prominent within the past ten years (Cho et al., 2013; Else-Quest et al., 2016a; Else-Quest et al., 2016b; Hyde, 2014), it has yet to be widespread in educational research (Codiroli-Mcmaster & Cook, 2019). Researchers acknowledge a primary challenge with intersectionality and quantitative research is the historical precedent of establishing pre-defined groups of participants and variables. Intersectionality research indicates such practices could lead to potential misclassification and obscure not only authentic relationships between individuals but the various and problematic power structures within society (Gross et al., 2016; Codiroli-Mcmaster & Cook 2019; McCall, 2005).

However, McCall (2005) who was one of the first researchers to explore intersectionality in quantitative studies, suggested researchers need to adopt categories for the short term to explore whether meaningful differences exist between groups of participants at the intersection of at least two analytic categories, such as gender and ethnicity. They further suggest the groups

should be compared systematically, such as when the mathematical performance of Latino male students is compared to the mathematical performance of white male students. In this case, the Latino male students should be the focus of analysis and the performance of white male students would provide the background for the comparison in the analysis.

Finally, it is important to mention that intersectionality in quantitative research should not be a replacement for qualitative research; these methods should work in concert with one another. Researchers such as Gross et al. (2016) and Gutiérrez (2008) acknowledge that intersectionality can and should be explored from both lenses, suggesting that as new findings and theories are developed through qualitative research, they should also be explored through a quantitative analysis. Similarly, if quantitative studies identify meaningful differences, qualitative methodology is well-suited to exploring why those differences exist.

Mathematical Performance and Ethnicity

Research has been conducted for decades regarding the achievement gap, and school reform bills have been passed to support academic excellence for all students. Despite these efforts, research shows academic disparities still exist between Latino/a and white students (Davis-Kean & Jager, 2014; NCES, 2020; Rambo-Hernandez et al., 2019). According to the National Center for Education Statistics [NCES] (2020), over the past thirty years, nationwide mathematical scores have increased within all ethnic groups measured during fourth grade. However, Rambo-Hernandez et al. (2019) examined the growth rate between white/Asian students and Latino/Black students between third through fifth grades in a large-scale study with over 64,000 participants spanning thirty-four states. Their analysis revealed that Latino/Black students' learning pace was at a lower rate than white/Asian students, resulting in a more significant disparity between these two groups of students during these specific timespans.

Intersectionality research asks researchers to shift the lens on how the achievement gap is studied. This means deemphasizing the goal of parity in favor of exploring whether the proportion of failures and successes amongst the groups are equal (Au, 2013; Scott, 2012). Davis-Kean and Jager (2014) offered a perspective of a within-group study of the achievement profiles of ethnic groups to examine the variance of achievement levels within each group. They collected longitudinal data from the Early Childhood Longitudinal Study—Kindergarten Cohort (ECLS-K). Their findings suggest there are high performing students in all ethnic categories; European Americans, African Americans, Hispanic, and Asian Americans. Specifically, a within-group analysis of the Hispanic students revealed that in kindergarten, 13% of the students started out in the high performing group; by fifth grade, 52% of the students were categorized as high performing students (Davis-Kean & Jager, 2014). This study illustrates how, when achievement data is analyzed through a within-group lens, different patterns emerge, painting a picture not of disparities, but instead, revealing substantial growth within the Hispanic student group from kindergarten through fifth grade.

Mathematical Performance and Gender.

According to NCES (2020, 58-59), there have been no measurable differences between male/female fourth-grade mathematics scores for the past thirty years. The difference in scores between females and males in 1990 was one point, and in 2019 there was a three-point difference in their mathematical performance. These data points reveal that females and males have been performing similarly in mathematics for the past thirty years, with no measurable difference, leading researchers to investigate gender similarities instead of differences.

Mathematical Performance and Between Group Gender Analysis

Despite decades of research in the area of mathematical performance and gender, there is no noticeable difference between males and females. Hyde (2005) coined the gender similarities hypothesis, which suggested males and females were more similar than different on most but not all psychological variables. Hyde's research indicated no discernible difference in mathematical performance between males and females through their work from 1990 to 2014. Researchers who have found comparable results and support the gender similarities hypothesis include Lindberg et al. (2010) and Kane & Mertz (2012); their work indicates the gender gap in mathematics has diminished over time and males and females do not differ significantly in performance. Based on this evidence, one can surmise that while there is a slight difference in mathematical performance between males and females, overall, males are not overtly excelling in mathematical performance more than females when comparing mean scores between the two groups.

Mathematical Performance and Within Group Gender Analysis

While there are slight differences in mean scores between males' and females' math performance with insignificant magnitude, researchers do agree that males have greater variability in their mathematical performance than females (Breda et al., 2018; Else-Quest et al., 2010; Hyde, 1990, Hyde et al., 2008; Kane & Mertz 2012; Lindberg et al., 2010; Reilly, 2012). This suggests that when studies include a within-group analysis, there is a greater variance in high-performing and lower-performing students between males and females. These findings revealed that between-gender group analyses may be too broad to identify specific nuances of any identified gap. As researchers study the variance within a group, it could provide more detailed results. Disaggregating the data further may give the researchers more pinpointed insights into the similarities, differences, and variability in scores.

The remainder of this literature review explores the research on disruptions to learning and mathematical performance, the projected impact of the pandemic's learning disruptions, and empirical evidence that supports the need to further investigate the potential changes in mathematical performance during the pandemic.

Disruption to Learning and Mathematical Performance

The potential impacts on mathematical performance resulting from the pandemic have increased researchers' interest in measuring how academic disruptions affect learning loss in children (Hevia et al., 2022). Learning loss is the amount of knowledge that does not successfully transfer to students' long-term memory due to an absence from schooling (Huong & Teerada, 2020). Learning loss is commonly studied in connection with summer break, natural disasters, or absenteeism (Kuhfeld et al., 2020; Tomasik et al., 2020). However, a consideration worth noting is that while schools shut down in the spring of 2020, countries responded differently to school closures based on many factors, including access to technology, the spread rate of the virus, and other economic factors. Schools shut down anywhere from roughly eight weeks in Switzerland (Tomasik et al., 2020) to more than 48 weeks in Mexico (Hevia et al., 2022). Despite the disruption to in-person instruction, countries and school districts worldwide enacted emergency measures to keep children connected to the classroom via remote learning or distance learning (Hevia et al., 2022; Kuhfeld et al., 2020; Poletti, 2020; Tomasik et al., 2020). While teaching and learning continued during emergency school closures, there were significant disruptions to routines, curriculum plans, technology challenges, and inconsistency in home-based learning environments. All of these factors undoubtedly influenced teaching and learning, affecting students' performance in ways that need to be explored.

Academic Disruptions and Mathematical Performance

Early projection studies indicate that younger children at the elementary level are more likely to be impacted academically by school closures than older students (Kuhfeld et al., 2020; Panagouli et al., 2021; Poletti, 2020). Others have projected an increased achievement gap will result from pandemic-related school closures (Hevia et al., 2022; Poletti, 2020). These projections were substantiated by a noteworthy study from Kaffenberger (2020), who utilized a pedagogical production function model to simulate how much learning would likely occur between third and tenth grades, post-pandemic. Their simulation projected that students who attended fourth grade, who missed one-third of their third-grade year during the pandemic and received only grade-level content with no accelerated learning pathways to access grade-level content, would be more than a year behind in tenth grade. In contrast, the simulation revealed students in the tenth grade could indicate eleventh-grade performance levels if they had access to accelerated educational pathways (Kaffenberger, 2020). This suggests the importance of giving students multiple avenues to grade-level content by integrating prerequisite skills necessary to access grade-level content. School leaders and researchers strongly recommend this approach, particularly in light of the many disruptions to student learning over the past two years (Kaden, 2020; Kuhfeld. et al, 2020; NCTM, 2020; CGCS, 2020). These projections indicate the importance of school districts measuring and addressing their students' mathematical performance. Understanding the learning trends of groups of students during the pandemic as a way to monitor growth and learning patterns, could support accelerated learning pathways for all students.

Moreover, Kuhfeld et al. (2020) analyzed learning loss data from summer break, absenteeism, and natural disasters, such as hurricane Katrina. They predicted students who did

not receive remote instruction in the spring of 2020 likely entered school in the fall of 2020 only retaining roughly 37-50% of their learning in mathematics from the previous school year. At the same time, pandemic-related disruptions to mathematical learning have not yet unfolded. Despite this, early empirical evidence suggests that these forecasts may be somewhat predictive.

Latest Research on Mathematical Performance Related to Pandemic Disruptions

Empirical evidence surrounding the potential impact on mathematical performance during the pandemic is still emerging. Studies have identified decreased learning trends during the periods from spring of 2020 through 2021 compared to mathematical performance data collected before the pandemic (Dorn et al., 2020; Hevia et al., 2022; Meeter, 2021; Tomasik et al., 2020). This suggests that while researchers cannot say for sure that the pandemic caused the reduction in learning, there appear to be trends that signify the need to investigate this phenomenon further.

Meeter (2021) found that grades three through five experienced slower learning paces in mathematical performance during school closures than older students did. Other results reported by Hevia et al. (2022) through a comparative analysis at the intersection of gender and socioeconomic status revealed that higher-performing males learned at a slower pace than lower-performing females. These findings are important and support the need for further within-group analyses because it showcases the nuanced differences between males' and females' performance through a more pinpointed lens, which may not have been revealed through a between-group analysis based on the differences in mean scores.

Finally, Dorn et al. (2020) compared fall i-Ready mathematics diagnostic scores from 2019 to 2020. Their study discovered third-grade students in schools whose student minority population extended beyond 50% of the total student population learned only 54% of what they

would have learned in a typical year not impacted by school closures. These early results indicate a difference in learning pace between males, females, and ethnic minority students throughout the school closures. It is essential researchers continue to add to this body of knowledge to understand this phenomenon.

Summary

Based on the research conducted in mathematical performance, there is a need to study group differences and similarities through the framework of intersectionality with an analysis of the variables of gender and ethnicity, as measured by the i-Ready diagnostic assessment. This study could shed light on potential similarities and differences that emerged after a significant event. Additionally, this study could provide insight into how gender and ethnicity interact statistically with mathematical performance. This is important because a focus on mathematical performance at their intersections of gender and ethnicity can promote a mindset of excellence for all as opposed to perpetuating the narrative of a disparate gap while identifying current trends in mathematical performance during the pandemic.

Chapter Three offers the methodological plan for this study, outlining the research questions, limitations, delimitations, and sample of the study. The chapter concludes with a detailed description of the data analysis procedures and ethical considerations for this research.

Chapter 3: Methodology

This chapter outlines the research design of this study, including information regarding the sampling plan, instrumentation, how data was collected and analyzed, and ethical considerations.

This study examined three research questions:

1) Did the mathematical performance change in a rural Oregon school district between a group of students who were not impacted by school disruptions and a group of students who were impacted by school disruptions due to the global pandemic as measured by i-Ready scores?
2) Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latina and white female students as measured by i-Ready scores?
3) Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latino male and white male students as measured by i-Ready scores?

Purpose of the Study

The COVID-19 pandemic interrupted in-person education in Oregon for fifteen months. The impact of the pandemic likely affected achievement levels in mathematics, a possibility that needs to be investigated further. The purpose of this study was to discover if evidence of changes in mathematics performance before and during the pandemic existed. I used a quantitative research design and existing i-Ready diagnostic data to ascertain whether significant differences in mathematics scores were evident in a group of students who attended third and fifth grades before the pandemic. I then compared that analysis to students who attended third grade before

the pandemic and fifth grade during the pandemic. Specifically, this study examined whether differences were observable in sub-groups distinguished by students' gender and ethnicity.

Research Design

This study was a non-experimental post-hoc quantitative design. I employed a causal-comparative design to explore the potential relationships between the independent variables at the intersectionality of gender and ethnicity, and the dependent variable of mathematical performance. First, I compared two groups of students to establish whether significant differences in mathematical scores existed. Group A was comprised of students who attended third grade at OWSD during the 2017-2018 school year and fifth grade during the 2019-2020 school year, before the pandemic. Group B was comprised of students who attended third grade during the 2019-2020 school year before OWSD was impacted by the pandemic and fifth grade during the 2021-2022 school year while OWSD was still impacted by the pandemic. I discuss this first comparison in more detail under the Internal Validity heading further on in the chapter. After determining whether or not significant differences existed, the study focused on a within and between group analysis of Group B from third grade (2019-2020) to fifth grade (2021-2022) at the intersection of gender and ethnicity.

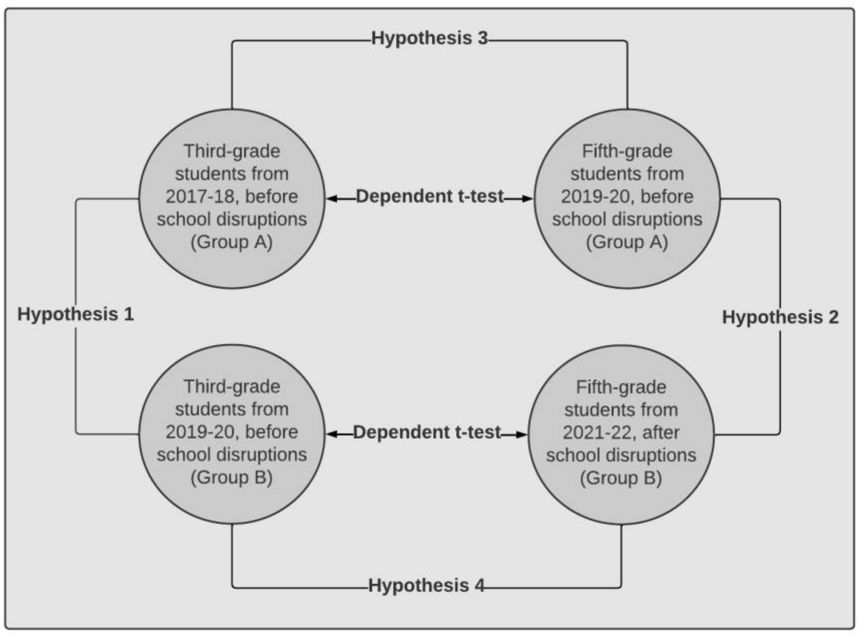
The independent variables were the focus of this study and were not manipulated in any way. Additionally, a critical component of a causal-comparative design is that it is retrospective in nature, meaning the comparison happened after an event has occurred (Salkind, 2010). In this case, the pandemic resulted in mandated school closures which have already occurred, and no variables were manipulated, making this a suitable design for this study. I chose this methodology because I explored whether or not mathematical performance changed during the pandemic at the intersectionality of gender and ethnicity constructs.

Research Questions and Hypotheses

Research Question 1: Did the mathematical performance change in a rural Oregon school district between a group of students who were not impacted by school disruptions and a group of students who were impacted by school disruptions due to the global pandemic as measured by i-Ready scores?

Figure 1

Hypotheses for Question One



H_o1: There is no significant difference between students' mean i-Ready mathematics scale scores in third grade before school disruptions between Groups A and B.

H_a1: There is a significant difference between students' mean i-Ready mathematics scale scores in third grade before school disruptions between Groups A and B.

H_o2: There is no significant difference between students' mean i-Ready mathematics scale scores in fifth grade before school disruptions (Group A) and in fifth grade after school disruptions (Group B).

H_a2: There is a significant difference between students' mean i-Ready mathematics scale scores in fifth grade before school disruptions (Group A) and in fifth grade after school disruptions (Group B).

H_o3: There is no significant difference between students' mean i-Ready mathematics scale scores within Group A from third to fifth grade before school disruptions.

H_a3: There is a significant difference between students' mean i-Ready mathematics scale scores within Group A from third to fifth grade before school disruptions.

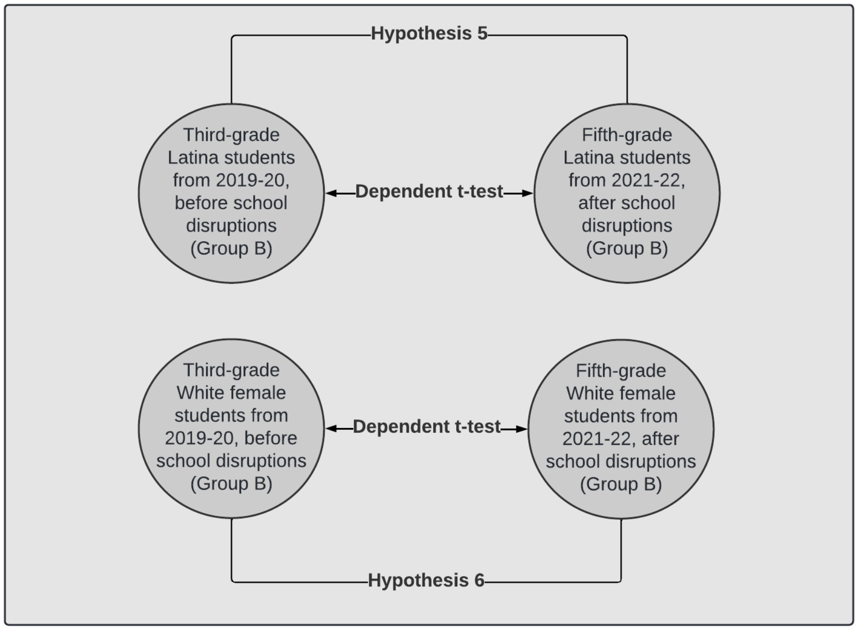
H_o4: There is no significant difference between students' mean i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade after school disruptions.

H_a4: There is a significant difference between students' mean i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade after school disruptions.

Research Question 2: Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latina and white female students as measured by i-Ready scores?

Figure 2

Hypotheses for Question Two



$H_0$5: There is no significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (Latina) within Group B from third grade before school disruptions to fifth grade after school disruptions.

H_a5: There is a significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (Latina)within Group B from third grade before school disruptions to fifth grade after school disruptions.

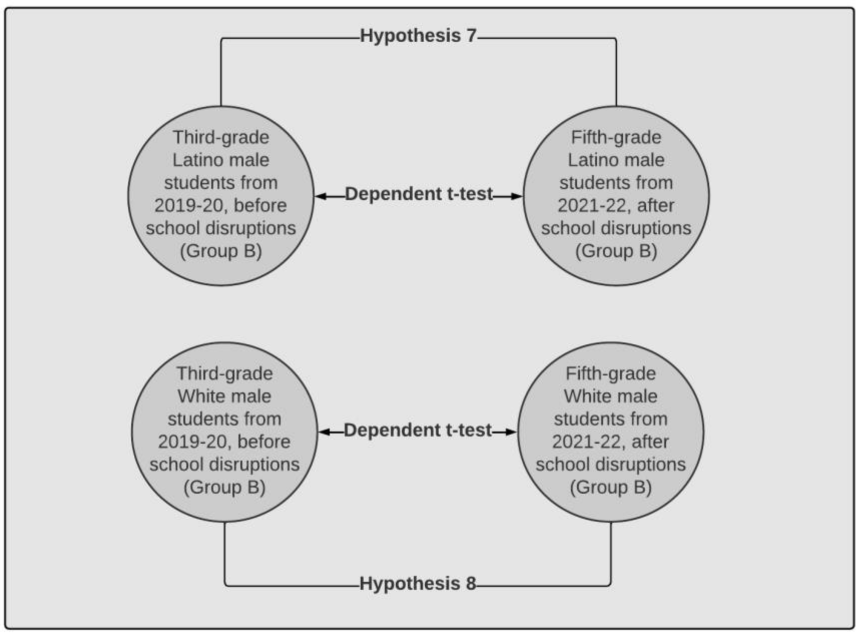
$H_0$6: There is no significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

H_a6: There is a significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

Research Question 3: Did the mathematical performance change in a rural Oregon school district before and after school disruptions due to the global pandemic between Latino male and white male students as measured by i-Ready scores?

Figure 3

Hypotheses for Question Three



$H_0$7: There is no significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (Latino male) within Group B from third grade before school disruptions to fifth grade after school disruptions.

H_a7: There is a significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (Latino male) within Group B from third grade before school disruptions to fifth grade after school disruptions.

$H_0$8: There is no significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (male white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

H_a8: There is a significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (male white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

Limitations of the Research Design

Since causal-comparative studies focus on an event that has already taken place, the researcher does not control either the events or the occurrences (Salkind, 2010). Therefore, I did not manipulate the variables, a fact that creates two limitations to this study. First, while I discussed potential relationships between and within the variables, the mathematical performance changes were not explicitly clear. Secondly, the results of this study could not be generalized to other contexts because of the inability of this method to construct random samples (Salkind, 2010).

Internal Validity

In order to strengthen internal validity, I examined whether or not there were significant differences in the mean i-Ready mathematics scale scores between a group of students who attended third and fifth grades before the pandemic (Group A) to a group of students who attended third grade before the pandemic and are currently in fifth grade (Group B), during the

pandemic. Establishing whether or not significant differences existed between these two groups provided a frame of reference for me to better understand to what extent the pandemic's disruptions to learning affected students' mathematical performance.

Hypothesis one compared the differences in the mean i-Ready mathematics scale scores between two groups of third-grade students Group A and B, both of whom attended third grade before the pandemic. Identifying whether these two groups' i-Ready scores were significantly different was key to the internal validity of this study. If these two groups were not significantly different, then the internal validity would have increased because it would have been more likely the change in mathematical performance patterns and trends occurred due to a significant event (such as pandemic-induced learning disruptions). If there was a significant difference, the internal validity of this study would have decreased because the groups would be determined to be dissimilar at the start.

External Validity

The results may be externally valid within the sampled third and fifth-grade elementary school students from a rural school district in Oregon. However, this study did not include a sample of urban third and fifth-grade elementary school students, and as such, the results are not generalize to the larger population. The results may also not be valid for third and fifth-grade students in any other time and location than this particular rural Oregon school district.

Population

The population of this study was rural Oregon elementary students from Oak Water School District who attended fifth grade during the pandemic.

Sample

Students whose education was interrupted in the spring of their third-grade year and continued through fourth grade during the COVID-19 pandemic entered fifth grade in the fall of the 2021-2022 school year. The COVID-19 pandemic disrupted learning at a time when these young learners were still developing early number sense skills (ODE, 2011). Geary et al. (2017) and Gersten's et al. (2005) research linked disruptions to early number sense learning to later difficulty in mathematical performance, indicating the potential significance of research exploring this issue. The sampling plan for this study was to utilize a convenience sample of an entire fifth-grade cohort (130 students) from a rural Oregon school district to explore the potential changes in mathematical achievement during the pandemic.

OWSD is a rural school district in Eastern Oregon. As of October 2020, OWSD had a student enrollment of 2,290 with an average class size of 22 students giving it a student-to-teacher ratio of 17:1. The demographic distributions of students are: < 1% American Indian or Alaska Native, < 1% Asian, < 1% Black or African American, 57% Hispanic or Latino/a, 2% Multiracial, < 1% Native Hawaiian or Pacific Islander, and 40% white (ODE, 2020b).

Instrumentation

The i-Ready diagnostic, developed by Curriculum Associates, is a computer-based adaptive assessment of mathematical performance. It is typically administered to students three times a year and gives results based on a scale from 100 to 800 (National Center on Intensive Intervention [NCII], 2021). The diagnostic assessment aligns with the Common Core State Standards (CCSS) and is designed to measure students' academic performance in mathematics and predict their performance on the Smarter Balanced Assessment (SBA). Both CCSS and SBA have been adopted by Oregon as essential components for teaching and assessment (Curriculum

Associates, 2020; ODE, 2011). The NCII (2021) provided convincing evidence that the i-Ready mathematics diagnostic is highly correlated to nationally adopted state assessment systems, such as SBA. The average correlation between the two assessments in grades three through eight is .89 (Curriculum Associates, 2020; NCII, 2021). This means students' mathematical performance on the i-Ready diagnostic is a high indicator of their performance on the SBA in mathematics.

Data Collection Procedures

After this study was approved by the dissertation committee and Institutional Review Board (IRB), I was granted written consent from a rural Oregon school district to access stored, archived mathematical data for Group A who attended third and fifth grades before the school disruptions due to pandemic and Group B who attended third grade before the school disruptions due to the pandemic and fifth grade after the school disruptions due to the pandemic. Before the school district released the data, a district representative ensured all identifying information for students was removed. The data was also disaggregated according to the variables pertinent to the study: ethnicity and gender.

Operationalizing Variables

Dependent variable. The dependent variable was math achievement as measured by the winter i-Ready mathematics diagnostic for students in third grade (Groups A and B) and fifth grade (Groups A and B). Classroom teachers administered the diagnostic three times each subsequent year, in the fall, winter, and spring, except for spring 2019 due to the COVID-19 pandemic. Each student took the i-Ready diagnostic assessment independently, moderated by the classroom teacher with no assistance, accommodations, or modifications.

Independent variables. The independent variables were ethnicity and gender.

Ethnicity. The second research question used ethnicity as an independent variable. Upon registering for school, parents identified their child's ethnicity as American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino/a, Multiracial, Native Hawaiian or Pacific Islander, or white; this information was recorded, synced into the i-Ready platform, and stored in the district-wide archived database. After obtaining the mathematical performance data, it was determined that there were no students in the following categories: American Indian or Alaska Native, Asian, Black or African American, Multiracial, or Native Hawaiian or Pacific Islander. This means the designation for ethnicity was either white or Latino/a.

Gender. The third research question used gender as an independent variable. Upon registering for school, parents identified their child's gender as male or female, this information was recorded, synced into the i-Ready platform, and stored in the district-wide archived database. This means the designation for gender was either male or female.

Data Analysis Procedures

Research question one focused on the differences between the mean i-Ready scale scores in mathematics between Groups A and B. Group A attended third grade during the 2017-2018 school year and fifth grade during the 2019-2020 school year, both of the i-Ready diagnostic assessments were administered before OWSD was impacted by the pandemic. Group B attended third grade during the 2019-2020 school year and fifth grade during 2021-2022 school year. The i-Ready diagnostic assessment was administered during the 2019-2020 school year before OWSD was impacted by the pandemic. The i-Ready diagnostic assessment was administered during the 2021-2022 school year, while students were present at school, but still impacted by the pandemic. I analyzed winter i-Ready diagnostic scores from winter 2017-2018 and 2019-2020, for group A and winter 2019-2020 and 2021-2022, for group B using independent t-tests to

determine if significant differences existed between the mean i-Ready scores between independent groups. Assumptions for an independent t-test include (a) one continuous dependent variable, (b) one independent variable, with two categorical, independent groups, (c) independence of observations (different participants in each group), (d) the data set contains no significant outliers, (e) the distribution is approximately normally distributed, and (f) there is a homogeneity of variance. I explored the existence of Assumption D using boxplots and explored assumption E using the Shapiro-Wilk test of normality. Finally, assumption F was explored using Levene's test of equality of variances (Laerd, 2015a). These analyses helped me identify if Group B was similar to Group A before the pandemic and if mathematical performance changes occurred during the pandemic; this provided the foundation for the subsequent analysis of questions two and three.

Additionally, I conducted and analyzed dependent t-tests to determine whether significant differences existed between the mean i-Ready scores of two related groups. Assumptions for a dependent t-test include (a) one continuous dependent variable, (b) one independent variable, with two categorical related groups, (c) the data set contains no significant outliers, and (d) the distribution is approximately normally distributed. Assumption C was explored using boxplots and assumption D was explored using the Shapiro-Wilk test of normality. The assumption of normality was violated using the dependent t-test for hypothesis eight, which resulted in an additional test, the Wilcoxon Signed Rank test (Laerd, 2015b). The within-group analysis of group A yielded the mathematical performance trends for a group of students who attended regular, in-person school before the pandemic between third and fifth grades. A within-group analysis of Group B revealed the mathematical performance trends for a group of students who experienced fifteen months of interrupted schooling due to the pandemic. I compared these

trends to determine similarities and differences in mathematical performance trends and patterns for a group of students in fifth grade during the pandemic.

Research question two focused on the differences between the mean i-Ready scale scores in mathematics within Group B. I conducted two dependent t-tests, disaggregated by gender and ethnicity; both of these groups were from third grade before the pandemic compared to fifth grade during the pandemic. One of the t-tests was used for Latina students and the other was for white female students. I analyzed both of these within-group t-tests to explore mathematical performance trends and patterns during the pandemic. Specifically, I analyzed significant differences within the groups and the magnitude of potential differences. Then I compared and contrasted the findings from these analyses between the group of Latina students to the group of white female students. Where the group of Latina students was the focus of analysis and the performance of white female students provided the background for the compare and contrast in the analysis.

Research question three focused on the differences between the mean i-Ready scale scores in mathematics within Group B. I conducted two dependent t-tests, disaggregated by gender and ethnicity. Both of these groups were from third grade before the pandemic compared to fifth grade during the pandemic. One of the t-tests was for Latino male students and the other was white male students. I analyzed both of these within-group t-tests to explore mathematical performance trends and patterns during the pandemic. Specifically, I analyzed significant differences within the groups and the magnitude of potential differences. I then compared and contrasted the findings from these analyses between the group of Latino male students to the group of white male students. Where the group of Latino male students was the focus of analysis

and the performance of white male students provided the background for the compare and contrast in the analysis.

Ethical Concerns

I obtained IRB approval from George Fox University before the onset of the study. There was minimal risk of harm associated with this study since all student identities were obscured. The privacy of all student performance data and school identities associated with this study is of high importance. I obtained prior written consent from the district before collecting and analyzing data. A gatekeeper provided requested data and coded the appropriate variables to ensure I did not have any identifying information connecting students to their performance data. All potential identifying information obtained through data collection has been and will continue to be kept confidential in a password-protected database. I will maintain the data files for three years following the completion of the study. At that point in time, I will permanently delete all files and associated data related to OWSD.

Summary

This study was a non-experimental post-hoc causal-comparative study. It was designed to explore potential relationships between the independent variables at the intersection of gender and ethnicity focusing on the dependent variable of mathematical performance. This study analyzed mathematical performance trends and patterns within Latina, Latino male, white female, and white male groups to identify whether and to what extent changes occurred during the pandemic between third and fifth grades. In Chapter Four, the results of this study are reported, specifically focusing on how the mathematical performance trends and patterns changed during the pandemic within each group outlined.

Chapter 4: Results

The COVID-19 pandemic interrupted in-person education in Oregon for fifteen months. The impact of the pandemic likely affected achievement levels in mathematics, a possibility that needs to be investigated further. The purpose of this study was to explore whether or not mathematical performance changed during the pandemic for a group of fifth-grade students at the intersectionality of gender and ethnicity.

This chapter outlines the results of null hypotheses one, two, three, four, five, six, seven, and eight. The assumptions of the statistical tests and the extent to which the data met those assumptions will be described.

Results of Hypothesis 1

Statistical analysis upheld the null hypothesis: There was no significant statistical difference between students' mean i-Ready mathematics scale scores in third grade before school disruptions between Groups A and B.

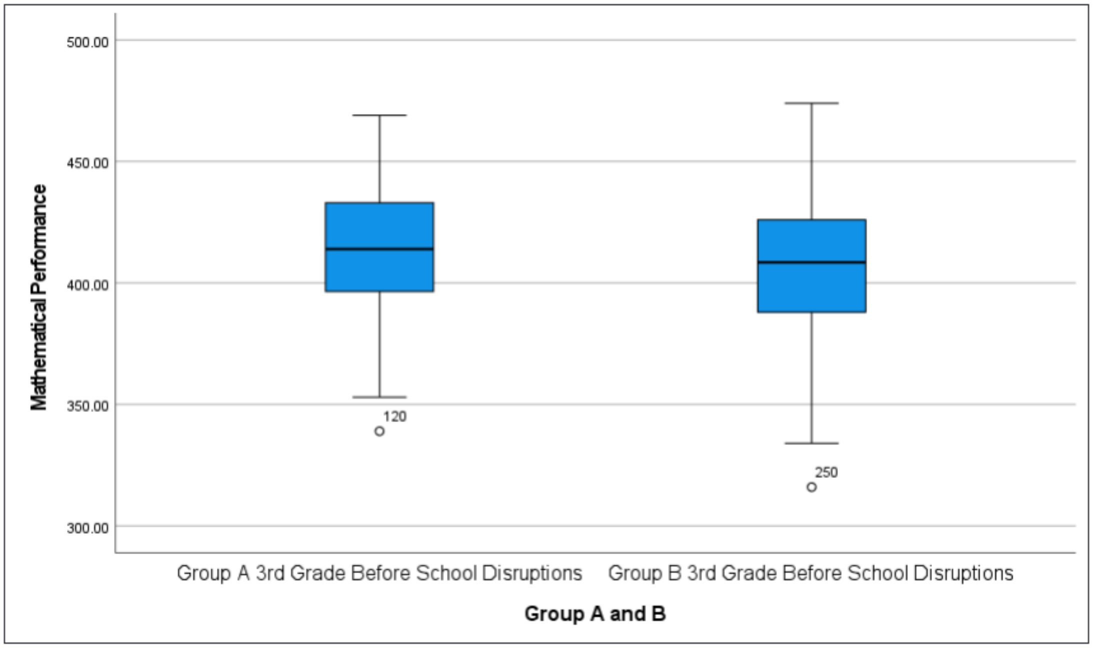
Table 1. Independent samples t-test, Group A and B before school disruptions

Group	Mean	n	SD	df	t	p
Group A 3rd Grade	413.11	120	26.4	248	1.90	0.058
Group B 3rd Grade	406.42	130	29.06			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 1. There were 120 participants in Group A (3rd grade) and 130 participants in Group B (third grade) An independent-samples t-test was run to determine if there were differences between students' mean i-Ready mathematics scale scores in third grade before school disruptions between Groups A and B. Two outliers were detected that were more than 1.5 box lengths from the edge of the box in a boxplot, see figure 4. Inspection of their values did not reveal them to be extreme and they were kept in the analysis. i-Ready

Figure 4

Boxplot for Hypothesis One



mathematical scale scores for each group were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot. See figures 5 and 6, respectively. There was homogeneity of variances, as assessed by Levene's test for equality of variances (p = .286). The average third-grade i-Ready mathematics scale scores for group A (M=413.11, SD=26.4) were slightly higher than the average third-grade scores from Group B (M=406.42, SD=29.06), there was not a statistically significant difference, M = 6.69, 95% CI [-0.24, 13.63], t(248)=1.90 p=.058, d= .24 between means (p>.05), and therefore, we can accept the null hypothesis.

Results of Hypothesis 2

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores in fifth grade before school disruptions (Group A) and in fifth grade after school disruptions (Group B).

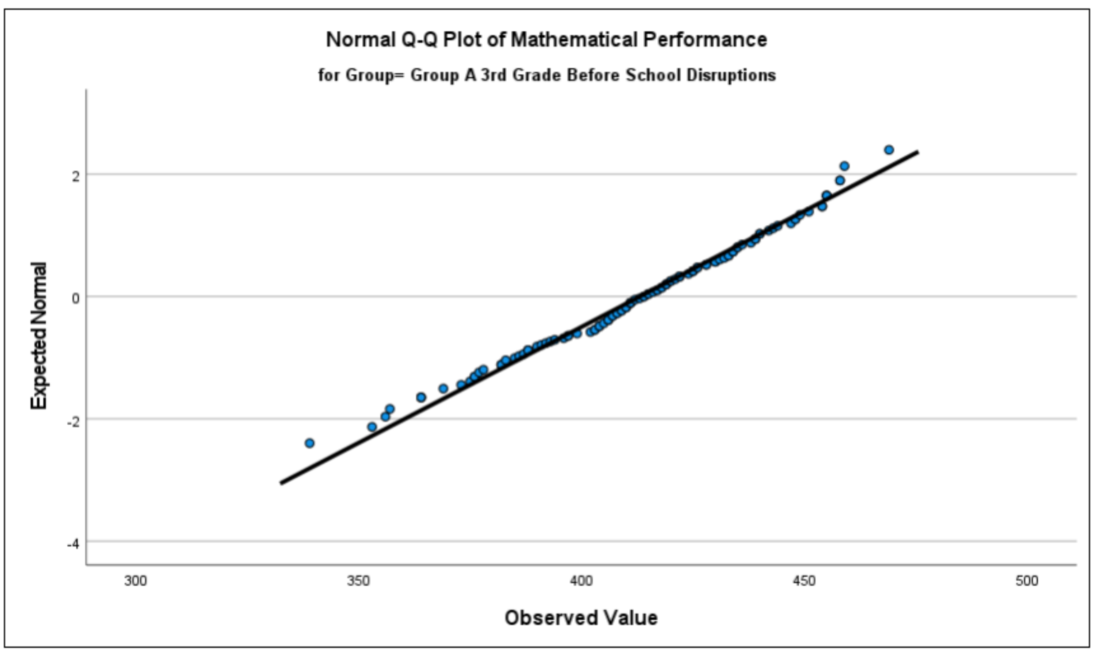
Table 2. Independent samples t-test, before (Group A) and during (Group B) school disruptions

Group	Mean	n	SD	df	t	p
Group A 5th Grade	454.54	120	28.19	248	2.47	0.014
Group B 5th Grade	445.06	130	32.06			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 2. There were 120 participants in Group A (fifth grade) and 130 participants in Group B (fifth grade) An independent-samples t-test was run to determine if there were differences between students' mean i-Ready mathematics scale scores in fifth grade

Figure 5

Normal Q-Q Plot--Hypothesis One



before school disruptions (Group A) and after school disruptions (Group B). Seven outliers were detected that were more than 1.5 box lengths from the edge of the box in a boxplot and one

Figure 6

Normal Q-Q Plot--Hypothesis One

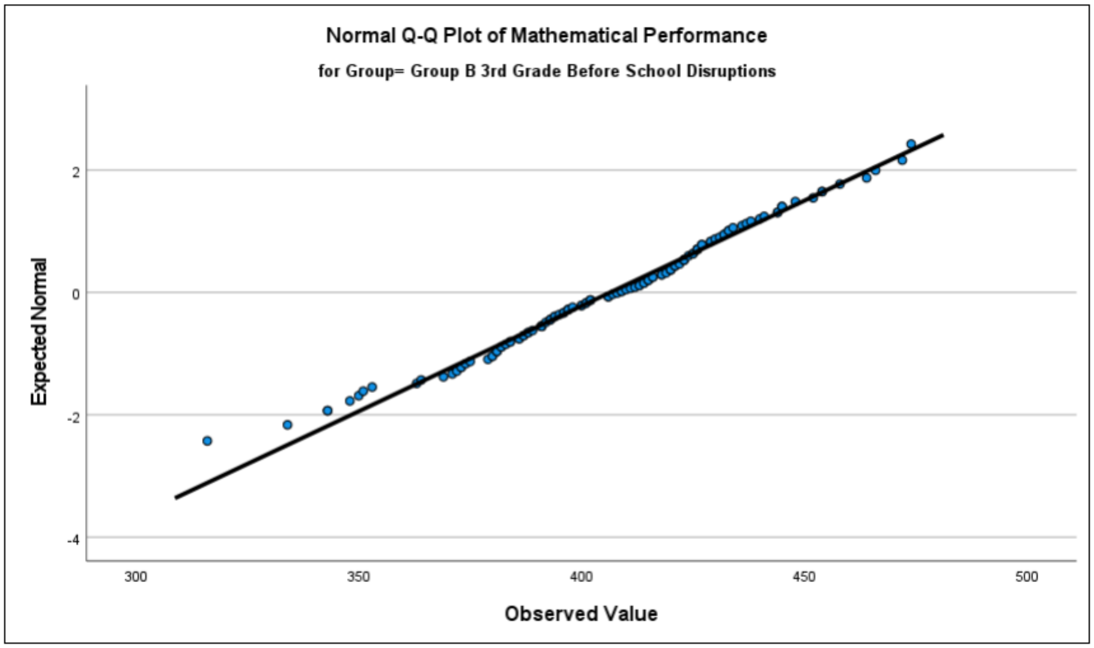
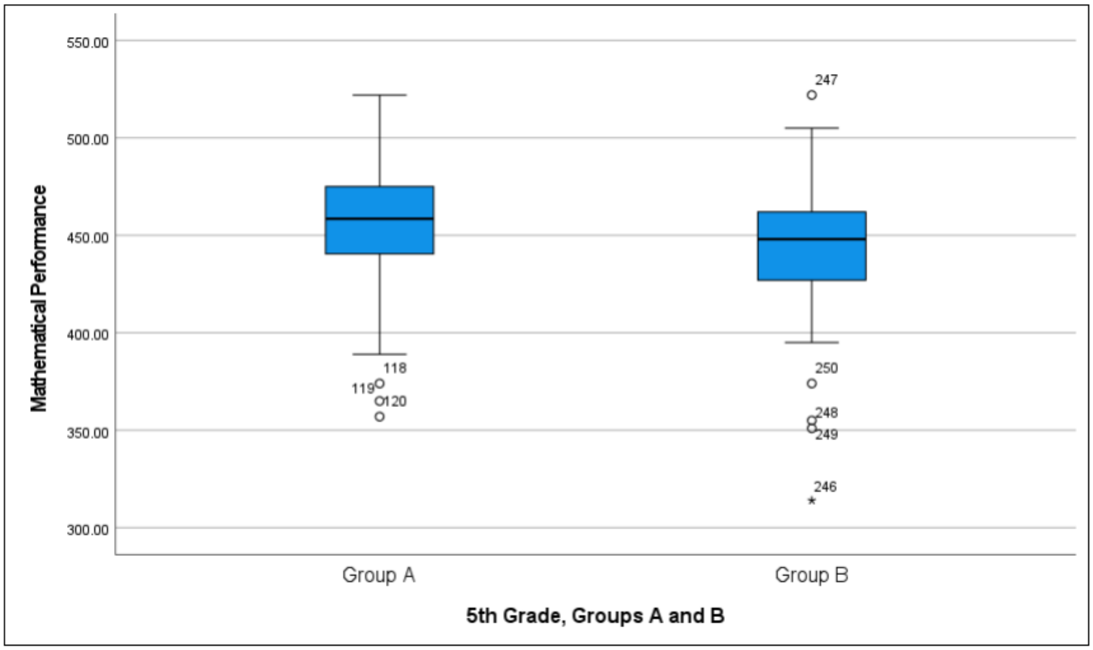


Figure 7

Boxplot for Hypothesis Two

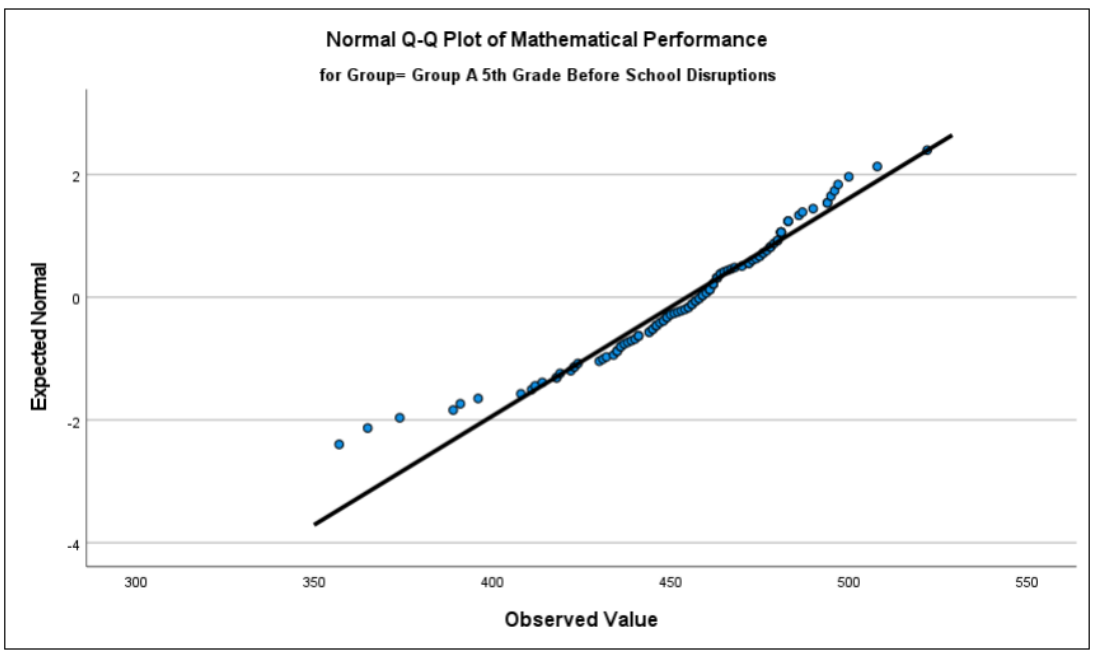


extreme outlier was identified as being 3 box lengths away from the edge of the box in the

boxplot, see figure 7. Inspection of their values did not reveal them to impact the overall results and they were kept in the analysis. i-Ready mathematical scale scores for each group were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot, see figures 8 and 9, respectively, and there was homogeneity of variances, as assessed by Levene's test for equality of variances (p = .254). The average fifth grade i-Ready mathematics scale scores for Group A (M=454.54, SD=28.19) were higher than the average third grade scores from Group B (M=445.06, SD=32.06), there was a statistically significant difference, M = 9.48, 95% CI [1.93, 17.03], t(248)=2.47 p= .014, d= .31 between means (p<.05), and therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 8

Normal Q-Q Plot--Hypothesis Two



Results of Hypothesis 3

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores within Group A from third to fifth grade before school disruptions.

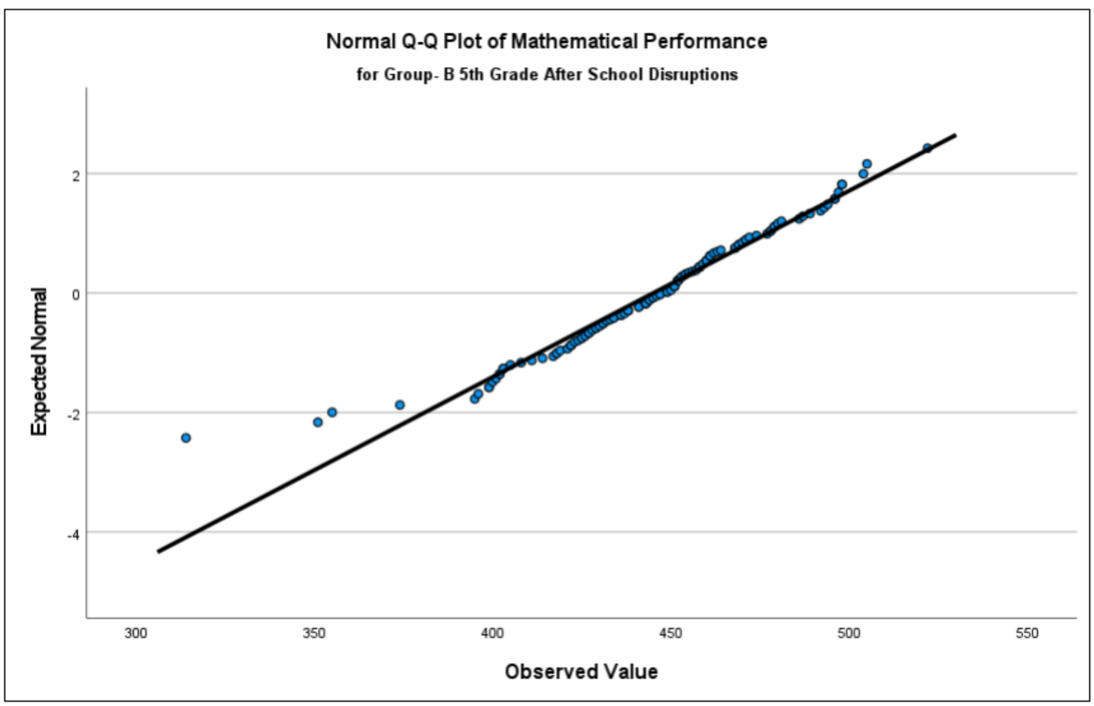
Table 3. Dependent samples t-test, Group A before school disruptions

Group	Mean	n	SD	df	t	p
Group A 3rd Grade	413.11	120	26.4	119	26.28	<.001
Group A 5th Grade	454.54	120	28.19			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 3. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between students' i-Ready mathematics scale

Figure 9

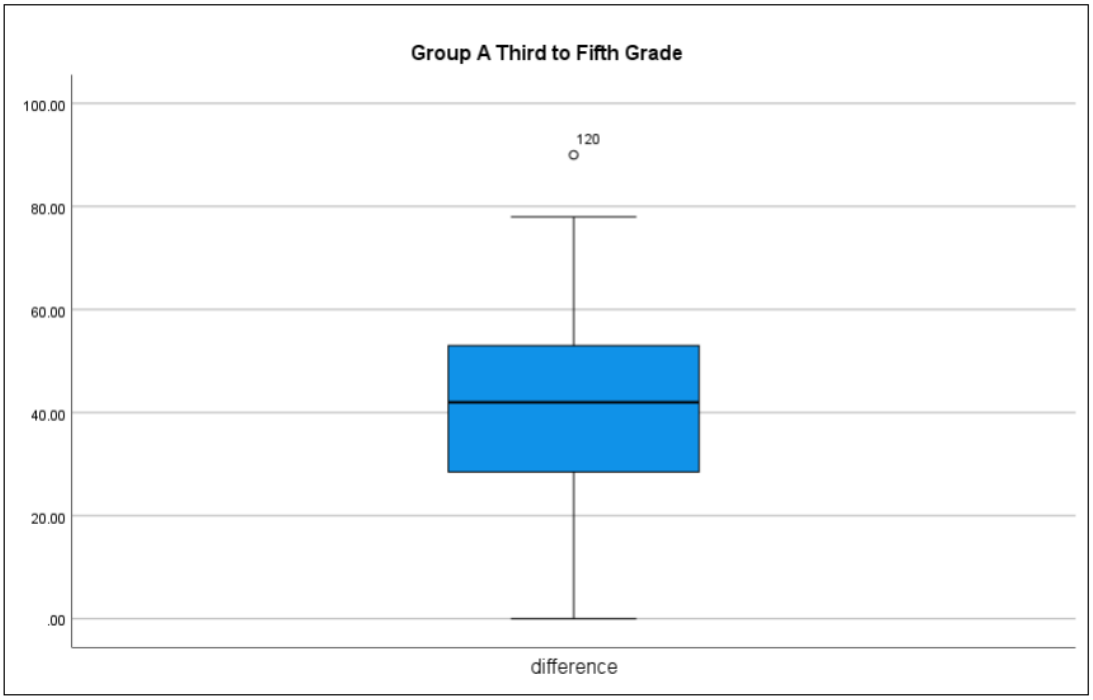
Normal Q-Q Plot--Hypothesis Two



scores within Group A from third to fifth grade before school disruptions. One outlier was detected that was more than 1.5 box lengths from the edge of the box in a boxplot, see figure 10. Inspection of this value did not reveal extreme differences in the results and it was kept in the analysis. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (*p* = .811). Fifth grade students (Group A) scored higher on their i-Ready mathematics assessment (M=454.54, SD=28.19) than they did in third grade (M=413.11, SD=26.4), an extremely statistically significant mean increase of 41.43, 95% CI [38.31, 44.56], t(119)=26.28 p= <.001, *d* = 2.40. The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 10

Boxplot for Hypothesis Three



Results of Hypothesis 4

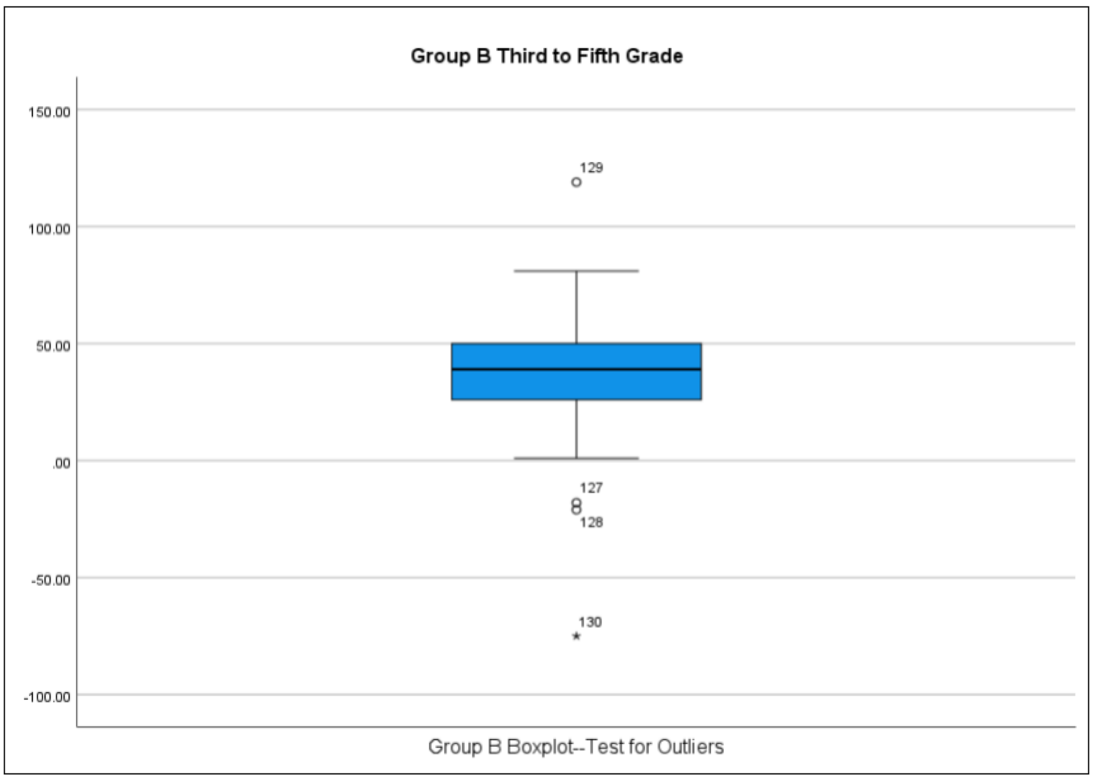
Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade after school disruptions.

Table 4. Dependent samples t-test, before (3rd grade) and during (5th grade) school disruptions

Group	Mean	n	SD	df	t	p
Group B 3rd Grade	406.42	130	29.06	129	19.76	<.001
Group B 5th Grade	445.06	130	32.06			

Figure 11

Boxplot for Hypothesis Four

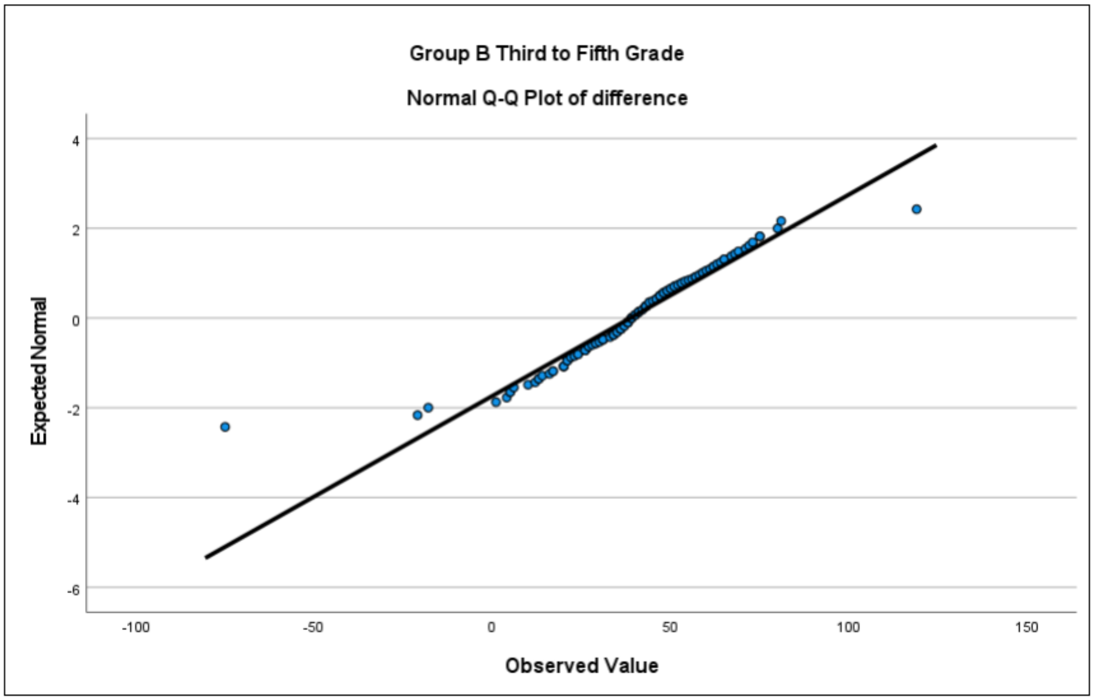


The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 4. A paired-samples t-test was used to determine whether

there was a statistically significant mean difference between students' i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade during school disruptions. Three outliers were detected that were more than 1.5 box lengths from the edge of the box in a boxplot and one extreme outlier was identified as being 3 box lengths away from the edge of the box in the boxplot, see figure 11. Inspection of their values did not reveal them to impact the overall results and they were kept in the analysis. The assumption of normality was not violated, as assessed by visual inspection of a Normal Q-Q Plot, see figure 12. Fifth grade students (Group B) scored higher on their i-Ready mathematics assessment (M=445.06, SD=32.06) than they did in third grade (M=406.42, SD=29.06), an extremely statistically significant mean increase of 38.65, 95% CI [34.78, 42.52], t(129)=19.76 p= <.001, *d* = 1.73. The

Figure 12

Normal Q-Q Plot--Hypothesis Four



mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Results of Hypothesis 5

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (Latina) within Group B from third grade before school disruptions to fifth grade after school disruptions.

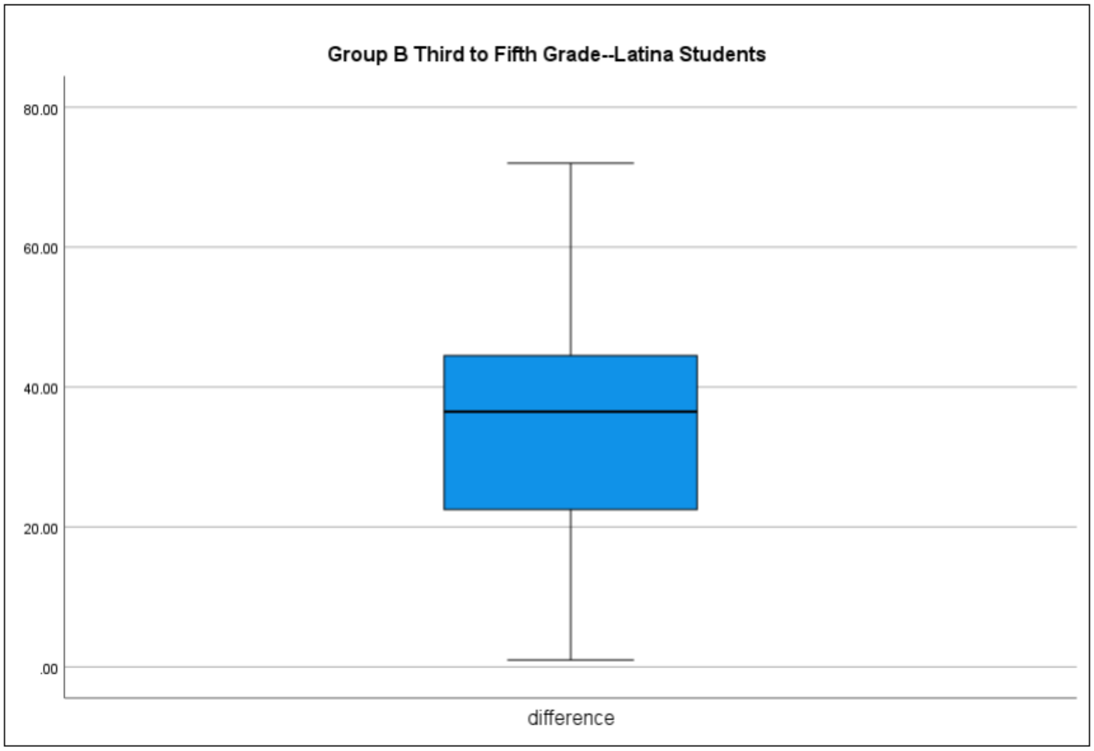
Table 5. Dependent samples t-test, before (3rd grade) and during (5th grade) school disruptions

Group	Mean	n	SD	df	t	p
Group B 3rd Latina	405.85	48	22.16	47	15.31	<.001
Group B 5th Latina	441.08	48	22.76			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 5. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between Latina students' i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade after school disruptions. There were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box lengths from the edge of the box, see figure 13. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (p = .846). Latina students (Group B) scored higher on their fifth grade i-Ready mathematics assessment (M=441.08, SD=22.76) than they did on their third grade assessment (M=405.85, SD=22.16), an extremely statistically significant mean increase of 35.23, 95% CI [30.60, 39.86], t(47)=15.31 p= <.001, d = 2.21. The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 13

Boxplot for Hypothesis Five



Results of Hypothesis 6

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores between gender (female) and ethnicity (white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

Table 6. Dependent samples t-test, before (3rd grade) and during (5th grade) school disruptions

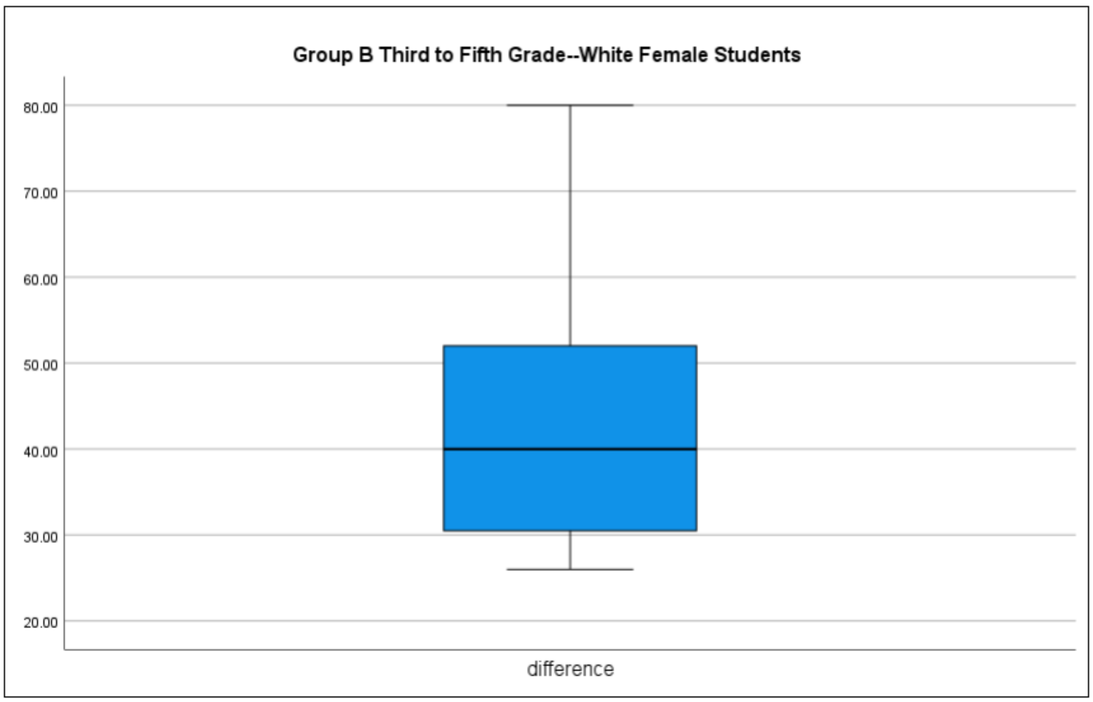
Group	Mean	n	SD	df	t	p
Group B 3rd White Female	420.87	15	30.07	14	10.88	<.001
Group B 5th White Female	464.2	15	24.47			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 6. A paired-samples t-test was used to determine whether

there was a statistically significant mean difference between white female students' i-Ready mathematics scale scores within Group B from third before school disruptions to fifth grade after school disruptions. There were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box lengths from the edge of the box, see figure 14. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (p = .208). White female students

Figure 14

Boxplot for Hypothesis Six



(Group B) scored higher on their fifth grade i-Ready mathematics assessment (M=464.2, SD=24.47) than they did on third grade assessment (M=420.87, SD=30.07), an extremely statistically significant mean increase of 43.33, 95% CI [34.79, 51.88], t(14)=10.88 p= <.001, d = 2.81. The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Results of Hypothesis 7

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (male Latino) within Group B from third grade before school disruptions to fifth grade after school disruptions.

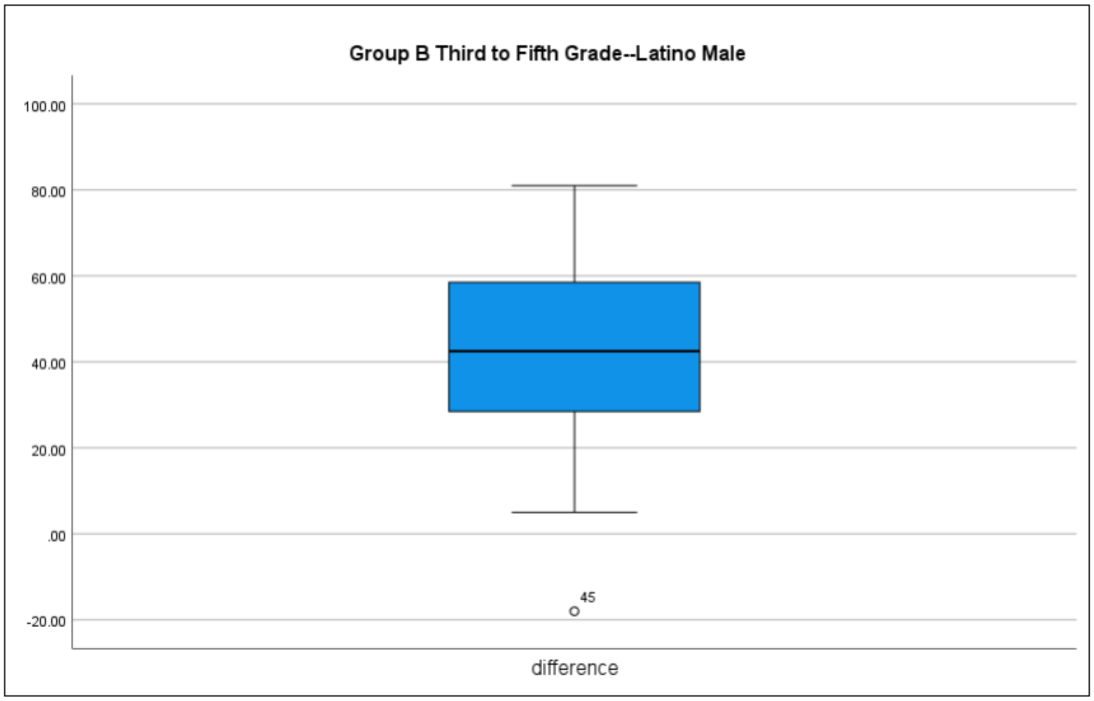
Table 7. Dependent samples t-test, before (3rd grade) and during (5th grade) school disruptions

Group	**Mean**	**n**	**SD**	**df**	**t**	**p**
Group B 3rd Latino Male	398.25	44	31.67	43	12.86	<.001
Group B 5th Latino Male	440.05	44	33.68			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 7. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between Latino male students' i-Ready mathematics scale scores within Group B from third grade before school disruptions to fifth grade after school disruptions. One outlier was detected that was more than 1.5 box lengths from the edge of the box in a boxplot. Inspection of their values did not reveal them to be extreme and it was kept in the analysis, see figure 15. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (*p* = .614). Latino male students (Group A) scored higher on their fifth grade i-Ready mathematics assessment (M=440.05, SD=33.68) than they did in third grade assessment (M=398.25, SD=31.67), an extremely statistically significant mean increase of 41.80, 95% CI [35.24, 48.35], t(43)=12.86 p= <.001, *d* = 1.94. The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 15

Boxplot for Hypothesis Seven



Results of Hypothesis 8

Statistical analysis rejected the null hypothesis: There is a significant difference between students' mean i-Ready mathematics scale scores between gender and ethnicity (male white) within Group B from third grade before school disruptions to fifth grade after school disruptions.

Table 8. Dependent samples t-test, before (3rd grade) and during (5th grade) school disruptions

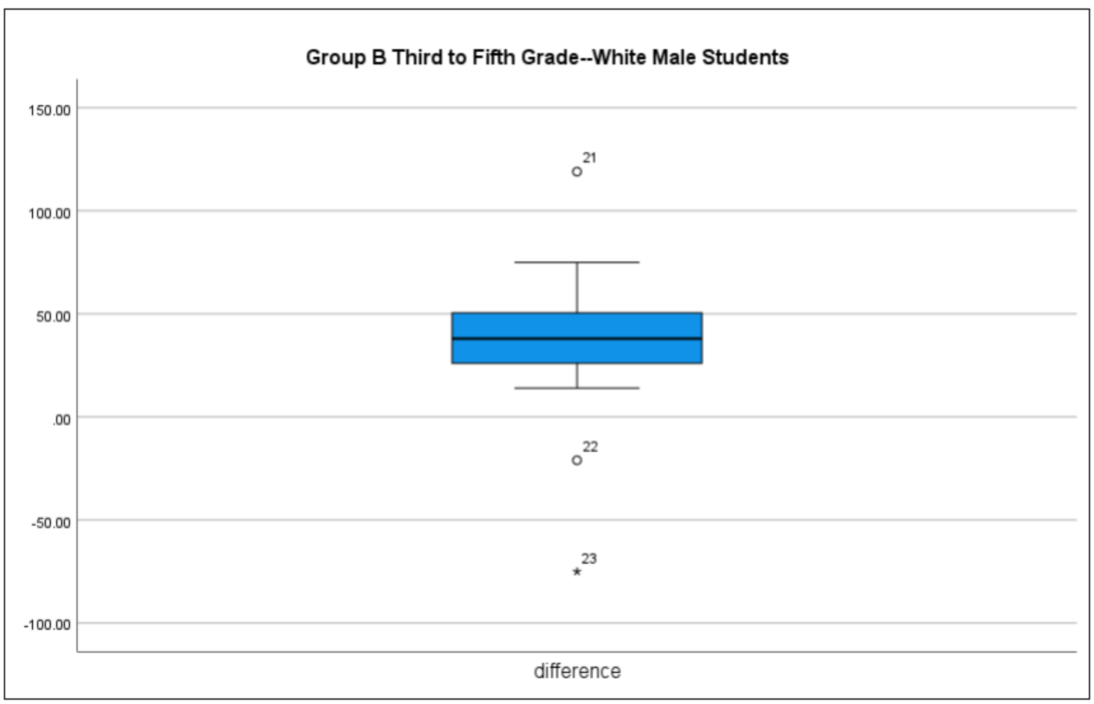
Group	Mean	n	SD	df	t	p
Group B 3rd White Male	413.78	23	32.14	22	4.98	<.001
Group B 5th White Male	450.48	23	44.23			

The statistical means of the i-Ready mathematics scale scores and the standard deviations of the participants are presented in Table 8. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between white male students' i-Ready

mathematics scale scores within Group B from third before school disruptions to fifth grade after school disruptions. Two outliers were detected that were more than 1.5 box lengths from the edge of the box in a boxplot and one extreme outlier was identified as being 3 box lengths away from the edge of the box in the boxplot, see figure 16. Inspection of their values did not reveal them to impact the overall results and they were kept in the analysis. The assumption of normality was violated, as assessed by Shapiro-Wilk's test (p = .004). White male students (Group B) scored higher on their fifth grade i-Ready mathematics assessment (M=450.48, SD=44.23) than they did on their third grade assessment (M=413.78, SD=32.14), an extremely statistically significant mean increase of 36.70, 95% CI [21.43, 51.97], t(22)=4.98 p= <.001, d = 1.04. The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 16

Boxplot for Hypothesis Eight



Since the assumption of normality was violated, I conducted a Wilcoxon signed-rank test, yielding similar results as the dependent t-test and therefore increasing the validity of the results. There was a statistically significant increase in mathematical performance (Mdn = 38.0) in fifth grade (Mdn = 46.0) compared to mathematical performance in third grade (Mdn = 420), $z = 3.48$, $p < .001$.

Summary of the Findings

This section offers a brief summary of findings for each research question, along with an explanation of the relevance of each question to the larger study seeking to understand changes in students' mathematical performance during the pandemic.

Research Question One

Research question one was important for establishing whether fifth-grade students' mathematical performance changed during the pandemic. First, I analyzed data from two groups of third-grade students from two different academic years to determine whether there was a difference in their scores between years. Both groups took the i-Ready assessment in pre-pandemic years and neither group experienced learning disruptions due to the school closures. Results showed both groups performed similarly in third grade under typical educational conditions.

I analyzed these same student groups' fifth-grade i-Ready scores to see whether there were differences in their scores under circumstances where one group of fifth-grade students experienced school normally and the other experienced school disruptions. Group A took the i-Ready assessment in pre-pandemic years; Group B took the i-Ready assessment during the pandemic and associated school closures. Comparisons between these groups show practical and significant differences: Group A had higher i-Ready scores than their Group B peers. This suggests the school closures may have adversely affected Group B.

The final objective of question one was to establish a baseline for typical or expected growth in students' mathematical performance between grades three and five. Group A students took both of their i-Ready assessments during pre-pandemic years and did not experience learning disruptions due to school closures. Group B took their third-grade i-Ready test pre-pandemic and took their fifth-grade i-Ready test during the pandemic, meaning they were affected by school closures. I used Group A's mathematical performance growth from third to fifth grade (M= 41.43) as a baseline for an expected rate of growth between third and fifth grade for Group B (M= 38.65).

Research Question Two

The second research question was important for helping me understand the mathematical performance trends for different student groups. For this question, I focused on Group B students, specifically Latina and white female students who took their third-grade i-Ready test pre-pandemic and took their fifth-grade i-Ready test during the pandemic. The results showed Latina students' (M= 35.23) in Group B experienced statistical (p= <.001) and practical significance (*d* = 2.21) in their growth between third and fifth grades. However, it was less growth than what Group A's students experienced under typical learning conditions (M=41.43 p= <.001, *d* = 2.40).

In comparison, growth rates for white female students' (M= 43.33) from Group B were statistically (p= <.001) and practically (*d* = 2.81) significant. White female students also grew more than expected, compared to expectations established by Group A comparisons (M=41.43 p= <.001, *d* = 2.40).

Research Question Three

For the third research question, I focused on Group B students, specifically Latino male and white male students who took their third-grade i-Ready test pre-pandemic and took their fifth-grade i-Ready test during the pandemic. The results showed that Latino male students' (M= 41.80) in Group B experienced statistical (p= <.001) and practical (d = 1.94) significance in their growth between third and fifth grades. Latino male students also grew more than expected, given expectations established by Group A comparisons (M=41.43 p= <.001, d = 2.40).

In comparison, growth rates for white male students' (M= 36.70) from Group B were statistically (p= <.001) and practically (d = 1.04) significant in their growth between third and fifth grades. However, it was less growth than what Group A's students experienced under typical learning conditions (M=41.43 p= <.001, d = 2.40).

Summary

These results are specific to students in one rural school district in Oregon and indicate differences in students' mathematical performance may have been related to school closures. Latina, Latino, white female, and white male students all experienced statistical and practical differences in mathematical performance during school disruptions. However, in relation to Group A's growth trends, Latino male and white female students experienced higher-than-expected growth, whereas Latina and white male students experienced lower-than-expected growth.

This chapter outlined the results of this study, including information regarding the sampling plan, instrumentation, how data was collected and analyzed, and ethical considerations. The next chapter offers an analysis of findings from this study including implications, recommendations, and conclusions.

Chapter Five: Results

The purpose of this study was to discover if fifth-grade students in one rural school district evidenced significant differences in mathematical performance related to pandemic-based school closures. This study compared within and between gender and ethnicity-based groups of students both before and during the pandemic. Existing data for students in Oak Water School District were collected from the i-Ready winter mathematics diagnostic assessment for academic years 2017-18, 2019-20, and 2021-22.

This quantitative, non-experimental, causal-comparative post-hoc study was retrospective in nature, which means the study relied on existing test scores. Variables of mathematical performance, gender, and ethnicity were not manipulated in any way. The statistical tools used to test assumptions were the Shapiro-Wilk to test for normality, Levene's test of equality of variances to test for homogeneity of variance, and boxplots to identify outliers. The researcher used several statistical tools to interpret the results, including mean, median, independent t-test, dependent t-test, Wilcoxon Signed-Rank test, p-value to test for statistical significance, and Cohen's d to test for practical significance. This chapter presents implications, recommendations for practice and future research, and conclusions. The next section briefly reviews the implications of this study. This discussion is framed by an intersectionality framework or the notion that social structures such as gender and ethnicity interact on multiple levels, resulting in unique experiences, opportunities, and barriers (Crenshaw, 1991; Cho et al., 2013, Codiroli-Mcmaster & Cook; McCall, 2005).

Implications

There were three research questions in this study, designed to compare mathematical performance scores for students who tested before the pandemic to those who tested during the

pandemic. The first question explored whether students' mathematical performance, as measured by the i-Ready assessment, changed during the pandemic. Research questions two and three sought to discern potential differences in mathematical performance at the intersectionality of gender and ethnicity. By disaggregating the data into gender and ethnicity-based groups, the analysis revealed more nuanced differences for students affected by school closures. This is important to identify and discuss because one of the foundational components of intersectionality as noted in the literature (Codiroli-Mcmaster & Cook, 2019; Crenshaw, 1991; Gutiérrez, 2008; Hyde, 2005; McCall, 2005) is ensuring each group is analyzed individually. Doing so deemphasizes the mistaken idea that educational equality means all groups need to reach parity with one another. When educators evaluate groups individually, they can better discern whether they are making similar progress as other groups and determine a single group's progress as compared to itself, which is a more equitable way to draw comparisons than comparing one group to another group. The following discussion aims to accomplish this objective.

The analysis included Group A students who took the i-Ready assessment in third and fifth grades, in pre-pandemic years with no learning disruptions, and Group B, who took the i-Ready assessment in third grade in a pre-pandemic year and again in fifth grade during pandemic-related school closures.

Research Question One

1. Did the mathematical performance for students in a rural Oregon school district change when comparisons are drawn between a group of students who were not impacted by school disruptions and a group of students who were impacted by school disruptions, as measured by i-Ready scores?

Data analysis for this question revealed that fifth-grade students who were impacted by school disruptions did not experience expected growth in their mathematical performance between third and fifth grades. This suggests school disruptions did affect these students, which is aligned with other research identifying decreased learning trends during the spring of 2020 through the 2021 school year (Dorn et al., 2020; Hevia et al., 2022; Meeter, 2021; Tomasik et al., 2020). Possible explanations for these trends may be due to reduced student attendance (Kuhfeld et al., 2020; Tomasik et al., 2020) or inefficient technology (Hevia et al., 2022). Such factors can impact students in rural school districts more heavily since these districts are geographically more spread out than urbanized areas (Hart et al., 2005; Lavalley, 2018). Although reduced growth in mathematical performance may be due to school disruptions, there are many other factors that could have been influential in shaping these results.

Despite a lack of clarity on the specific reasons for decreased growth, such numbers are nevertheless significant in inviting Oak Water School District to examine their current mathematical structures and systems to ensure they consider pertinent prerequisite skills and accelerated learning progressions for all students.

The next section explores to what extent mathematical performance changed for students at the intersection of gender and ethnicity in Group B, who evidenced reduced growth in mathematical performance compared to Group A. These students took the i-Ready assessment in third grade in a pre-pandemic year and again in fifth grade during pandemic-related school closures.

Research Questions Two and Three

2. Did the mathematical performance change in a rural Oregon school district during school disruptions due to the global pandemic between Latina and white female students as measured by i-Ready scores?
3. Did the mathematical performance change in a rural Oregon school district during school disruptions due to the global pandemic between Latino male and white male students as measured by i-Ready scores?

Within-group analysis of the data for research questions two and three revealed that fifth-grade Latina and white male students did not experience expected or typical growth between third and fifth grades; their mathematical performance did change, but not as much as expected when compared to Group A.

Additionally, a within-group analysis of the data revealed that fifth-grade white female and Latino male students in Group B made expected growth in their mathematical performance between third and fifth grades. Both of these groups actually surpassed the expected or typical growth compared to Group A. The results indicate that the mathematical systems and structures that are in place at OWSD might be serving white female and Latino male students well, but may be detrimental to Latina and white male students.

There are other unexplored factors that extend beyond school systems that could have played a role in the mathematical performance of the students at OWSD. Such factors include the extensive change in family dynamics experienced by many families during the pandemic. For example, role shifts such as children taking on more household chores (Sheen et al., 2021), changes in the amount of parental support children received, and students experiencing a lack of motivation and social interactions (Balayar & Langlais, 2022) are factors that may have shaped

students' academic achievement levels. While it was not within the scope of this study to explore these possibilities, it is important to note that these could be contributing factors to the performance levels of students during school disruptions.

Questions two and three sought to understand to what extent any differences in mathematical performance occurred between groups of fifth-grade students for these sub-groups: Latina, white female, Latino male, and white male students. Data revealed Latino male and white female students experienced above-expected, typical growth, and Latina and white male students experienced below-expected, typical growth. The next section explores these between-group differences and similarities.

Between Group Analysis

According to Au (2013) and Scott (2012), an achievement gap can be defined as whether the number of successes and failures between student groups is proportionally equal. This means, for example, that if there was a 30% score difference between groups of students in the first grade, there would be a roughly 30% difference between those same groups in the third grade, indicating they both grew to their potential and the gap between them did not widen. The results from this study indicate that both Latina and white female students and Latino male and white male students grew significantly from third to fifth grades, but they did not grow proportionally to one another. This suggests that school disruptions may have affected Latina and white male student groups more significantly than Latino male and white female student groups.

The growth rate of white female students (M= 43.33) between third and fifth grade was higher compared to Latina students (M= 35.23), which suggests they did not grow proportionally to each other, thus increasing the achievement gap. This increase in the achievement gap aligns with the current literature regarding the notable academic disparities which have existed between

ethnic minority and white students for decades (Davis-Kean & Jager, 2014; NCES, 2020; Rambo-Hernandez et al., 2019).

Likewise, the growth rate of Latino male students (M= 41.80) was higher compared to white male students (M= 36.70). Although the gap narrowed a bit (somewhat differently than expected), such results do not necessarily indicate a closing of the achievement gap since they did not grow proportionally.

These results are important because they revealed different trends than the projections identified by Dorn et al. (2020), whose research predicted differences in learning growth between males, females, and ethnic minority students throughout school disruptions. Instead, this study revealed that white female students and Latino male students actually performed similarly to one another, as did white male students and Latina students. In short, this study revealed that, in isolation, neither gender nor ethnicity seemed to shape students' mathematical achievement.

Limitations and Future Research

This study's limitations include the study design being causal-comparative, which limits the generalizability of the results. A second limitation involves the use of the i-Ready assessment as a measurement tool. Future research exploring mathematical performance changes during the pandemic using more robust measures and larger sample sizes should be utilized. Additionally, future research could benefit from an intersectionality study with a qualitative study design to explore possible reasons the changes in mathematical performance were evident. The following section will explore these limitations and recommendations for future research.

Two limitations to this study are important to discuss. First, the results of this study cannot be generalized to the larger population because the study design was causal-comparative with a convenience sample consisting of one school district. Secondly, the i-Ready diagnostic

assessment data used for this study is not widely used to track and monitor mathematical growth, making it a limitation to this study. A suggestion for future research that would address both of these limitations is to conduct a study using random samples from multiple school districts and use a more reliable and valid measurement than i-Ready. It would be useful to study this with a more universally-accepted assessment tool, such as state achievement scores often collected through NAEP, PISA, or TIMMS. These measurements could provide a more accurate account of how mathematical performance changed during the pandemic and would increase the generalizability of the study. The results can be compared to the findings of this study, which could strengthen the validity or provide different perspectives that were not revealed during this study.

The literature indicated that intersectionality in quantitative research should not be a replacement for qualitative research (McCall, 2005). This study identified meaningful differences in mathematical performance between Latino/a and white male and female students. These differences could be related to school disruptions induced by the pandemic. However, the conclusions cannot be firmly stated that the differences in mathematical performance were correlated to school disruptions. Future research within the Oak Water School District communities could be expanded to include a qualitative study to explore why these differences exist. A qualitative intersectionality study could help gain a deeper understanding of how the school disruptions impacted the communities of OWSD. It could also provide a more well-rounded understanding of the impact of the pandemic within this rural community. A qualitative intersectionality study may provide personal insights, experiences, or human aspects of the impact of school disruptions that went undetected in this study. There could be other contributing factors that may explain why the increased disparities within Latina and white male students'

mathematical performance existed. A deeper understanding of cultural norms or familial obligations that Latina and white male students may have encountered during the school closures may shed light on why these differences were revealed within this study.

Recommendations for Practice

The main focus of this study was to explore whether or not mathematical performance changed during the pandemic at the intersectionality of gender and ethnicity constructs. This section offers a discussion of recommendations for practice, supported by the findings of this study and the literature.

Educational Leaders and Policy Makers

Examining mathematical performance trends through an intersectionality lens of gender and ethnicity provides educational leaders and policymakers insights into how mathematical performance trends changed during the pandemic for historically underserved, underrepresented, or otherwise overlooked groups in the research. Specifically, the results of this study revealed reduced mathematical achievement levels during the pandemic for a group of fifth-grade students in a rural Oregon school. However, the results of this study also showed that Latino male and white female students experienced above-expected, typical growth, and Latina and white male students experienced below-expected, typical growth. The results of this study are important and timely because they revealed nuanced differences in mathematical performance through a more pinpointed lens, which was not revealed through a between-group analysis based on the differences in mean scores. Educational leaders and policymakers should consider analyzing mathematical performance trends at the intersectionality of gender and ethnicity as they attend to the critical work still needed for educators to provide an equitable education for all students. This could support the calls for shifting the narrative around achievement gaps from one of helping

everyone achieve parity to one that embraces and fosters equity for each group of students based on their needs during the pandemic.

District Leaders

The findings from this study indicated that Group B collectively experienced decreased mathematical learning trends during the pandemic. However, after analyzing the disaggregated data by gender and ethnicity, differences in learning patterns emerged between the groups. Specifically, this study revealed that, in isolation, neither gender nor ethnicity seemed to shape students' mathematical achievement. This is important because public education often tracks student groups, sometimes making erroneous assumptions based on hidden biases (Brunner, n.d; NCTM, 2020; Stoddard, n.d.). School leaders at OWSD should develop a unified vision of embracing and fostering equity for all students.

This shift in thinking calls for thoughtful conversations about what it means to lead a school through the lens of equity (Lindsey et al., 2013; Oregon Leadership Network, 2013). Barton & Larson (2012) described this as acknowledging and discussing biases, equity misconceptions, and modeling equity beliefs. Often when equity is discussed, it is through the lens of fostering and embracing minority students academically and cultivated through the school system. While this could be an essential aspect of equity, it is a far more complex topic. Through this lens, white male students could be overlooked as not needing additional support, although the results of this study indicated otherwise.

Principals and school leaders play a vital role in building and developing the relationship between school and community (Anderson, 2008). Leveraging equity through the lens of opportunity for all could be critical. Family and school collaboration are its foundational structure, bringing together the expertise of family, school, and community to intentionally plan

for the success of all students. To do this, as described by O'Neil et al. (2019), school leaders should offer a clear and concise explanation of what barriers families face regarding their ability to engage in their child's education and then implement equitable practices that negate those barriers. Given the inequitable results of this study regarding Latina and white male students, OWSD should focus on intentional engagement within those families first and foremost. Finally, bringing together all stakeholders: school, community, policymakers, and family could perpetuate a systemic cycle that has never been seen before—inclusive for all, built by the people who live it.

School leaders and teachers at OWSD have spent the past five years prioritizing data-informed instruction, grade-level and school-wide collaboration, and district-wide consistency related to mathematics instruction and assessment. These structures may have contributed to the above-average growth experienced by Latino male and white female students. However, these same structures may have been detrimental to the academic achievement associated with Latina and white male students' mathematical performance. With that in mind, OWSD should systematically revisit the current mathematical systems and structures. Ensuring any inadvertent barriers or assumptions based on erroneous perceptions of mathematical readiness for all groups of students are discussed and modified.

Mathematical performance can be measured in many forms and has become increasingly important to school leaders and government entities. Since No Child Left Behind (NCLB) and subsequent policies, school funding has been tied to student achievement. As a result, harmful school practices such as tracking minority students into low-level mathematics classes (Fusarelli, 2004; Hursh, 2007) have become familiar across the country. The results of this study indicated that students experienced disruptions in mathematical learning, potentially missing meaningful

learning opportunities necessary to develop advanced concepts. Leaders at OWSD should make careful decisions that support accelerated learning opportunities for all students, regardless of student gender or ethnicity. School leaders cannot lose sight of the purpose of using mathematical performance data to inform decisions at the local level. There is not a one-size-fits-all way to measure mathematical performance and achievement. School leaders should use all mathematical measurements available to gain a broader understanding of how students are performing. This includes state assessment measures as required by the federal government. Awareness of current trends and patterns gives a more comprehensive picture of where students need improvement. On a local level, this study indicates how mathematical measurements, such as the i-Ready diagnostic assessment, can be a valuable tool for understanding growth trends. It can also help school leaders pinpoint areas of strengths and weaknesses within an educational system.

School leaders need to take responsibility for understanding the mathematical trends of sub-groups of students in their respective districts. Assumptions and generalizations should not be made based on large student groups or national trends. It is important for school districts to be proactive in developing systems and structures that support the unique needs of their students and ensure they are not perpetuating the narrative that ethnic minorities are at a higher disadvantage than their white counterparts but instead promote an opportunity for all students.

Teachers

School leaders should recognize that the teachers are the greatest asset to the district. Skilled teachers shape learning moments over time (Clements & Sarama, 2014; Claessens & Engel, 2013; Fyfe et al., 2017; Rittle-Johnson et al., 2019; Siegler et al., 2011). OWSD experienced fifteen months of disruptions before the start of the 2021-22 school year, resulting in

missed opportunities for students to engage in meaningful learning activities and peer socialization (Almeida et al., 2021; Misirli & Ergulec, 2021; Prime et al., 2020). This study found that Latina students excelled at lower rates than white students. OWSD should promote and foster student agency, capacity, and belonging, which can be especially beneficial for Latino/a students (Turner et al., 2009) as schools settle back into regular, in-person classes. One way to do this is through project-based learning, which can bring together students in ways that build community and promote critical engagement which has been linked to higher mathematical achievement (Lazić et al., 2021; Turner et al., 2009). Project-based learning is intended to be student-focused and developed with real-life situations. Another benefit to project-based learning is that it promotes teamwork, critical thinking, and problem-solving (Lazić et al., 2021) in real-world settings, which is not always prominent in typical curriculum-based mathematics lessons.

Conclusion

This study explored the mathematical performance of a group of fifth-grade students in one rural Oregon school district to identify whether and to what extent their mathematical performance changed during the pandemic at the intersection of gender and ethnicity. This study focused on intersectionality from an educational perspective that aimed to promote a mindset of excellence for all students instead of perpetuating the narrative of ongoing gaps. This study identified current trends in mathematical performance during the pandemic and revealed both practical and significant differences in mean mathematical scores within Group B from third to fifth grade. However, Group B evidenced reduced growth rates compared to Group A. An examination of groups of students by their gender and ethnicity revealed more nuanced differences that were not obvious when analyzing data for the whole group; neither gender nor ethnicity solely shaped mathematical achievement. The use of these constructs in this study

exposed a need for teachers to explore ways to foster mathematical skills and embrace Latina and white male students during the recovery efforts of the pandemic. A qualitative study could offer new insights that this study could not provide. Finally, data revealed impressive mathematical growth between white female and Latino male students after school disruptions during the pandemic. As the global pandemic lingers, continuing research on this critical topic is crucial to gain a deeper, broader, and more comprehensive understanding of the potential changes in mathematical performance related to the pandemic.

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