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The Relationship Between Number of Instructional Minutes and Science and Mathematics Achievement in Elementary Schools

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ABSTRACT

The Next Generation Science Standards and the Common Core Mathematics Standards were created to assist U.S.A. school districts in providing the rigorous instruction needed to equip all students for college and career readiness and citizenship. Many minority students in the U.S.A. specifically, those in disadvantaged communities are still showing deficits in mathematics and science. The relationship between the number of instructional minutes and science and mathematics achievement of fourth grade students on the Northwest Education Association (NWEA) assessment was explored. Research questions addressed the degree of mathematics and science integration in school programming, number of minutes allocated to science and mathematics instruction, staff perceptions of mathematics and science achievement of fourth grade students, and the relationship between instructional minutes (time on task) and student achievement.

Primary and secondary data sources included master schedules and district and state protocols which guided teacher expectancy for delivery of instruction. All data and information were collected and gathered during the Covid-19 pandemic and analyzed using SPSS. During the time frame of study 100% remote learning conditions were in effect. The Carroll Model of Learning was adapted and used as the theoretical basis to determine time allocation and learning ratios of science and mathematics instruction.

Key findings based on the mathematics and science readiness instrument revealed that participating elementary school programs in mathematics and science were in an early stage of development. Student opportunities were afforded in both science and mathematics, but learning ratios computed using the Carroll Model for learning equation did not meet district levels of expectancy for student opportunities. Proficiency levels of the NWEA assessment in mathematics and science were below mean levels published at the national level for fourth grade students. Additionally, comparative achievement level data in science and mathematics revealed score gaps between certain student groups at the district, state, and national levels. A t-test analysis was used to reject the null hypothesis, there is no relationship between instructional time (time on task) and student achievement of fourth grade students in the areas of science and mathematics, at a 95% confidence level.

This dissertation is dedicated to my parents.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

The Next Generation Science Standards and the Common Core Mathematics Standards were created to assist U.S.A. school districts in providing appropriate instruction and the rigor needed to equip all students for college and career readiness. Yet, many students in the U.S.A. are still showing deficits in mathematics and science. As a science educator in the U.S., it is of vital importance to me that K-12 educators gain a better understanding of the role of the school in nurturing and growing a science and mathematics literate society. This knowledge of how the school impacts student interest and achievement in science and mathematics took an unexpected transition through a new lens of learning due to the Coronavirus 19 pandemic. This view of learning science and mathematics during the period of the pandemic is reflected in the study through recruitment, data collection, analyses, and conclusions. Reflection summaries from the perspective of the researcher are found at the end of chapters to better support an understanding of a period in society that presented a new level of challenges to teaching and learning, requiring a greater need of skillful pedagogy and content knowledge. The time frame in which the study was conducted spans just prior to the onset of the pandemic and during the pandemic.

Historically, education reform has been focused on ensuring citizens are literate and able to contribute to society and the needs of economic demands. Throughout the history of education reform, you will find that the incentive for transformational efforts in K-12 public schools focused on reading and mathematics. A Nation at Risk is a document published in 1983 by the National Commission on Excellence in Education and serves as a framework for research because it not only focused on reading and mathematics, but it also argued the importance of student achievement in other areas such as science (National Commission on Excellence in Education, 1983). The report revealed the lack of mathematics and science achievement of students in the U.S.A. at certain grade levels and ages in comparison to some international students in those content areas. The Commission concluded that deficiencies noted were attributed to inadequacies in four aspects of the education processes: content, time, teaching, and expectations (Nation at Risk, 1983). In plain language A Nation at Risk states that every student during that era in the U.S.A., regardless of socioeconomic status, will be provided the tools needed for their personal welfare, as well as the ability to benefit the society in which they live. Included in that report was a promise of hope and opportunity of future employment for all U.S.A. students who put forth a genuine effort. Thirty years later U. S. Labor Report data reflects the future of opportunity and hope is still limited for many minorities who are underrepresented in science and engineering. More recent national mathematics and science achievement results of studies such as the National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (Timms), and the Program for International Student Assessment (Pisa) all show that elementary students who are disadvantaged economically score lower than others in the areas of science and mathematics and this gap persists in later years. Reflective in the data of all three assessments are achievement gaps between scores of students who receive free and reduced lunch versus those who do not receive free and reduced lunch. These data sources are vital to any research regarding mathematics and science learning as they can provide a lens for understanding of what might be needed to foster learning in these subjects. Each assessment has its' own focus, giving a view from the perspective of content, literacy, and enrichment.

Continuing the work of a Nation at Risk is Public Law 102-62 that supports The Education Council Act of 1991, establishing the National Education Commission on Time and Learning called for a "comprehensive review of the relationship between time and learning in the nation's schools" (Kane, 1994, p. 3). The council revealed through its studies that one of the main challenges in U.S.A. school systems is the use of time in the instructional day and rated the appropriate allocation of time in schools across the U.S.A as deficient. Author Cheryl Kane (1994) labeled these students as "prisoners of time" (p.7). Throughout my experiences as a science educator teaching students and supporting staff in urban schools, the two most critical issues of teaching and learning directly impacting science and mathematics instruction in elementary settings are the time and the type of instruction provided. These two variables were considerably impacted during the COVID-19 pandemic and highly influenced by school and district culture, climate of science and math expectations, and curricula programs.

The No Child Left Behind Act (2001) and its revised counterpart Every Student Succeeds Act (2015) are two mandates the U.S.A Department of Education enacted to support state and local educational agencies to implement services and programs to better support academic performance. The NCLB Act targeted support for improving mathematics and emphasized reading on level at grade three to be on track for college and career readiness. The NCLB Act had adverse effects on some school communities, particularly those in disadvantaged neighborhoods that prioritized reading and mathematics instruction over other content areas, such as science and social studies. Messages of necessary improvement in these areas were a precursor for some institutions to restructure alignment of school calendars and instructional days for extension of time to teach the core subjects reading, mathematics, science, and social studies (NCES, 2012). Every Student Succeeds Act an amendment to NCLB provides support based on economic ability and outlines expectations for every student to be prepared for college and career readiness, which supported school programming intended to increase instructional time needed to adequately support both mathematics and science, particularly in urban elementary schools. While learning to read is essential for literacy, science and mathematics subject content and concepts are nonfiction literary devices with technical vocabulary and algorithms that provide problem solving and critical thinking skills necessary for advanced studies and career readiness. Research has shown that text complexity can be significant when supporting students with reading deficiencies. (Eckert, Gamon, and Lu 2013). Both NCLB and ESSA are important to growth and opportunity for urban schools and districts because they emphasize and monitor the progress or lack thereof in academic performance in underserved communities.

Other congressional initiatives to improve the quality of education in U.S.A. schools were incentives for higher education learning institutions and corporations to develop community outreach programs and informal learning targeting student exposure and experiences to various careers and 21st century skills needed to fill projected employment opportunities in the areas of science and mathematics (NCES, 2018). These initiatives also included input and voice from national science and mathematics organizations, such as the National Science Teaching Association, the National Science Foundation, and the National Council of Mathematics Teachers.

The U.S.A. Department of Education requires all K-12 public school districts to offer mathematics and science as part of their core curriculum program, and many post-secondary institutions require all students to take some form of science and mathematics prior to matriculation. However, national, and international data, such as NAEP (National Assessment of Educational Progress) and PISA (Program for International Student Assessment) indicate that some students in the U.S.A., especially those in disadvantaged communities, are falling short when it comes to proficiency levels in science and mathematics as compared to their peers in other countries. These two data sources showed a scaffolded gap of learning for students who received free and reduced lunch starting at the elementary school age and continuing through secondary schooling.

Students seeking employment in any natural science fields or mathematics are required to have advance coursework in science and mathematics as outlined in college preparatory programs for entry in these areas. Past research suggested "that many U.S.A. students are not prepared for the demands of today's economy and the economy of the future" (National Research Council, 2011, p.3). The National Research Council (2011) reported that "international students constituted more than a third of the students in U.S.A. science and engineering graduate schools, and more than 70 percent of those students currently remain in the United States after earning their degrees" (p. 3). The number of minority students, specifically Black student percentages in these areas are disproportionately lower. (National Science Board, 2018) These statistics have a direct impact on the inability to hire Black students and other students from disadvantaged communities in the U.S.A. due to lack of mathematics and science skills needed in the talent pool.

The Bureau of Labor Statistics forecasted an overly optimistic job outlook for those who are prepared to support the U.S.A. market in the areas of science, mathematics, engineering, and/or technology (National Science Board, 2018). The STEM Workforce Challenge (2007) is an executive summary that supported early research in preparation for a STEM workforce and provided a bleak outlook of the ability of the United States to compete globally in the areas of science and mathematics and stated growing STEM fields are increasingly central to the economic competitiveness and growth of the future in the U.S.A.

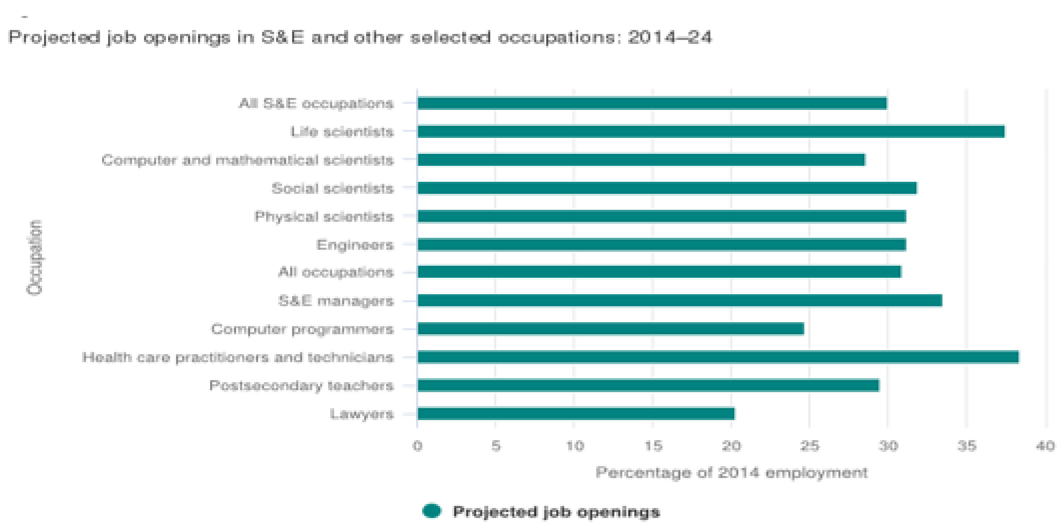
According to the STEM Workforce executive summary (2007) only about five percent of the U.S.A workforce was employed in one or more areas of science and mathematics with approximately 50% of the nations sustained economic growth leaning toward careers needing skill sets in science and mathematics. The summary stated the cause for many students not making it into a STEM career path is due to the lack of needed skills that should be gained in mathematics and science during the K-12 schooling. The latter statement was the theoretical basis for why time on task and student performance data collection specifically focused on mathematics and science achievement in elementary school settings.

In a report by the National Science Board (NSB, 2018), the committee illustrated the economic opportunities available to U.S.A. students who were prepared to pursue various careers using science and mathematics (see Figure 1). These opportunities provide an incentive to increase the talent pool to support a demand for enhancement of

U.S.A. STEM economy and provide hope for a better future for many underrepresented groups in the areas of science and mathematics. The projections shown in Figure 1 are based on a 10-year time frame (2014-2024) of prospective jobs in science and engineering (NSB, 2018).

Figure 1

Projected S&E Jobs 2014-24



Note: Figure 1 shows employment projections from the Bureau Labor Statistics.
Copyright 2015 Bureau of Labor Statistics.

Background of the Problem

Reform in science and mathematics education and a push for awareness of STEM opportunities and occupations should encourage youth to explore mathematics and science coursework and fields geared toward 21st century economic industry. While Trends in International Mathematics and Science Study (2019) results showed that youth in the U.S.A. elementary schools are outperforming other developed countries in their abilities in mathematics and science at specific grade levels, students in many disadvantaged communities, particularly urban areas, were not reflective in the data (TIMMS, 2019). Data from the National Center of Education Statistics revealed that only 35% of 4th grade students in the U.S. who participated in the 2019 NAEP assessment were proficient in science and 65% of those students at the fourth-grade level tested below the basic level of achievement (NAEP, 2019). Proficiency levels decreased as students were tested at higher grade levels. The data showed that proficiency levels of students tested at the eighth-grade level and twelfth grade levels in mathematics and science had percentage rates of basic to below basic ranging from 59% to as high as 78%. This data showed that students are either not retaining the concepts tested as they move vertically in their schooling or students are not understanding the concepts in earlier grade levels which does not extend what they already know but adds to what they do not know and understand. While some data revealed gaps are closing between underrepresented students and nonminority groups in some U.S.A. schools, in the Midwest, overall results nationally find that many minority students, particularly Blacks, are scoring well below white students in mathematics and science according to the most recent NAEP 2019 data.

Fall NAEP proficiency levels published in a midwestern school district for reading and mathematics at the fourth-grade levels are well below the published proficiency targets for 2019. Although the fourth-grade population studied did not have national proficiency levels shown for science this target population is vital because it created a space to examine policy of opportunities of early learning and equitable exposure (time) to science and mathematics through accountability. Currently there are two assessments used in the district that gauge proficiency levels in science and mathematics to compare against these targets. However, only one of the assessments (Northwest Educational Association) assessment tests the targeted population studied in both science and mathematics. The NWEA assessment is the proficiency level of achievement used for measurement of student performance and for purposes of this research it was used as a baseline to predict student readiness at fourth grade to meet the targeted proficiency levels at fifth grade where all core areas mathematics, science, and reading are tested. These proficiency levels are an indicator of not only challenges to cohort student performance for readiness on the fifth-grade mandated state assessment in a midwestern school district, but challenges for preparation for science and mathematics learning and opportunity in future years, as well. Currently the NAEP assessment is the only assessment representative of twelfth grade achievement at the national level and was researched for its association to preparation for college and career readiness. NAEP 2019 data showed a pattern of increasingly higher percentages of basic and below basic achievement for grades eight and grade twelve. The NAEP assessment is given every year in mathematics and reading but every four years in science. Based on the latest NAEP data (2019) proficiency levels for low income and Black students showed significant gaps of achievement levels between the minority and non-minority students with an even greater gap of performance shown based on socioeconomics of students who participated in free and reduced lunch. Table 1 shows state NAEP proficiency levels for mathematics and reading as no science proficiency levels were published.

Table 1

NAEP 2019 Fourth Grade Proficiency Levels for the Midwestern Population Studied

Year	Content	All	Low Income	Black	Hispanic	White
2019	Math	38%	27%	15%	32%	62%
	Science	Not Published	Not Published	Not Published	Not Published	Not Published
	Reading	36%	24%	19%	27%	52%

Note: NAEP 2020 Proficiency levels were not published due to the Coronavirus Pandemic. The modified table shows the published proficiency targets for science, mathematics, and reading for school years 2019 through 2021. The targets provide the percentage of total (All) students who are expected to meet proficiency, students who are eligible for free and reduced lunch based on socioeconomic data (Low Income), and students based on their ethnicity. In the public domain.

The midwestern state where this study was conducted published a 15-year (2018-2032) K-8 proficiency target chart in the areas of science, mathematics, and reading which predicted that all students would meet 90% proficiency in each area by 2032. Proficiency levels for mathematics are established for grades K-8, for science grades 5-8, and for reading grades K-8. The proficiency rates in all three subjects in the district have been below the expected published targets based on historical achievement level data. The proficiency targets are listed in Table 2 which were modified to show years 2019-2023 and the final year 2032 where all student levels of expected proficiency for mathematics, science and reading is 90%.

Table 2

State Proficiency targets by year 2019-2022 grades 5-8 Mathematics, Science, and Reading

Year	Content	All	Low Income	Black	Hispanic	White
2019	**Math**	42.58%	31.09%	27.10%	33.63%	49.88%
	Science	57.58%	44.34%	35.56%	46.97%	68.82%
	Reading	46.38%	34.70%	31.61%	37.16%	53.98%
2020	Mathematics	46.23%	35.62%	31.94%	37.97%	52.97%
	Science	60.25%	47.67%	39.75%	50.28%	70.45%
	Reading	49.74%	38.95%	36.10%	41.22%	56.75%
2021	Mathematics	49.87%	40.15%	36.78%	42.30%	56.06%
	Science	62.73%	51.20%	43.93%	53.59%	72.08%
	Reading	53.09%	43.21%	45.29%	40.59%	59.5%2
2022	Mathematics	53.52%	44.68%	41.62%	46.64%	59.14%
	Science	65.21%	56.90%	48.12%	56.90%	73.70%
	Reading	56.45%	47.46%	49.35%	45.09%	62.69%
2032	Mathematics	90%	90%	90%	90%	90%
	Science	90%	90%	90%	90%	90%
	Reading	90%	90%	90%	90%	90%

Note: Proficiency target for 2032 for Mathematics, Science and Reading for all students is 90%. Adapted from a midwestern SEA published proficiency target level chart in the public domain.

The performance measure used to assess fourth grade science and mathematics achievement for the data collection period were scores from the state benchmark assessment which was the NWEA. The assessment was given three times in the 2019-2020 school year in the fall, winter, and spring. The Fall 2020 assessment data was collected during the pandemic and expectations for performance of fourth grade students who participated in the study as well as the performance expectation for grade five are shown in Table 3.

Table 3

2020 Fall NWEA RIT Expectations Grade 4 & 5

	Science Achievement Norms		Mathematics Achievement Norms		Reading Achievement Norms	
Grade	Mean	SD	Mean	SD	Mean	SD
4	194.65	11.68	199.55	14.40	196.67	16.78
5	200.23	11.77	209.13	15.19	204.48	16.38

Note: Table 3 shows the expected Fall NWEA proficiency levels of performance in science, mathematics, and reading for the midwestern state and district in study. Fall NWEA assessment was used as the performance measure in study. SD is standard deviation. Source: District Assessment Office 2020.

Statement of the Problem

In a midwestern state the mathematics and science achievement of students in an urban school district are below the state and district norm. Due to the pandemic the last published midwestern high stakes test results published were 2019. The results showed that the science, reading, and mathematic achievement scores for the participating schools in the study were below state norms at proficiency levels expected in Table 3. The National Science Teaching Association supports the notion that inquiry science must be a basic in the daily curriculum of every elementary school student at every grade level including early childhood (NSTA, 2018). However, many elementary schools in urban settings have not prioritized science and mathematics as daily instruction. Science and mathematics achievement in elementary schools supporting underrepresented groups are not performing as well as other groups on national assessments (NAEP, 2019). It was my assumption that the low performance exists because of the limited amount of instructional time provided to students in the areas of mathematics and science in elementary school settings. While many educators and school leaders believe and understand the need to teach the core subjects (mathematics, science, social studies, and reading/ELA) only a few are willing to sacrifice the time to support both mathematics and science for fear of losing instructional time from teaching reading (Czernack, Demir, Johnson, Milner, Sonderfeld, 2012).

In the last decade, reform in science education focused on how to promote more learning in these subjects prior to secondary schooling. The National Research Council (NRC, 2001) posited that opportunities to learn remains one of the best predictors of student learning. Opportunities to learn science and math are impacted by various factors at different levels in urban K-12 education. Many of these factors impacting urban science and mathematics education in U.S.A. elementary school systems are linked to funding shortages which directly impacts resources, time, and instruction. The fact that many students are reading well below grade level exacerbate the problem. These factors diminish opportunities to learn leading to inequities of learning. Additionally, extensive demands on teacher and student time during the urban school day not only reduce time and effort on core content but also essential social and emotional behavior support, recess, and other encore courses such as art, music, and physical education all which are packed in a school day set by a standard number of required instructional minutes (Boyd and Hartman, 1998).

The relationship between amount of instructional time allocated to science and mathematics and student achievement were explored at the fourth-grade level. The influences of instructional time on student achievement as measured on the Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAP) mathematics and science achievement scores and student, teacher, and principal perceptions of science and mathematics learning in the elementary school settings were explored. Fourth grade students were chosen for the following reasons: 1) fourth grade is the grade level at which all students should have at least one year of prior exposure (third grade) to science which provides basic background knowledge and prerequisites for all students, 2) fourth grade standards are tested at the fifth grade level as a state benchmark for science performance on a grade span (3-5) assessment, and 3) the fourth grade level is assessed in both science and mathematics at the district, state, national, and international levels for comparison of U.S.A. student achievement to those of their peers at that age group and content in other countries. This grade level performance is an assumed predictor of cohort academic performance for student participants who will be assessed at fifth grade. All fifth-grade students who are eligible to test in a Midwestern state participate in their first of three required science assessments at grade five as mandated by the state law. This Midwestern state law requires all public-school students grades 3-5 to test in mathematics and all students at grade five to test in science. Table 3, p. 22 shows the targeted proficiency levels all fifth-grade students should achieve in mathematics and science, but it also revealed the challenges of knowing where students were in science due to the non-testing of students prior to fifth grade. Fourth grade data was used as a baseline predictor for cohort achievement levels at grade five in science and mathematics.

Theoretical Framework

The Carroll Model of Learning (1963) equation which focus on three qualities; opportunity, perseverance, and aptitude was used as the basis for computing the independent variable time on task as it pertains to student achievement. The Carroll Conceptual model components more applicable to the study was opportunity to learn and aptitude to learn. Due to remote learning conditions the component perseverance, time students are willing to learn, was not considered during the study because of modified scheduling. This study used the time needed to learn as a focus rather than perseverance. However, perseverance is evident for many students in the study in accordance with time on task during the NWEA assessment. As per Carroll (1963) time spent is the actual amount of time the student spends on learning and that theory is applied using the following formula:

Degree of Learning = f (time spent divided by time needed) (p.14).

The degree of learning was used to correlate the mean amount of time with student achievement in mathematics and science. This modification presents a new parameter I have named as Opportunities of Learning based on the time needed to learn mathematics and science and the opportunities provided to learn mathematics and science as it pertains to student achievement in these areas.

Purpose

One of the most vulnerable non-fiscal resources is time. Scheduling and allocating time regarding teaching and learning is one of the most important factors when considering programming and student needs to best accommodate conditions of optimal student learning. Through my experiences time is always the one factor that has been easily manipulated to accommodate instructional needs.

The purpose was to explore the relationship between time on task and student achievement in mathematics and science. Other factors explored in the study were staff perceptions of science and mathematics teaching and learning and the amount of time needed for effective learning. The Carroll Model of Learning Equation was used to indicate opportunities to learn science and mathematics of fourth grade students in an urban elementary setting.

Research Questions

1) To what degree are elementary schools making science and mathematics instruction an integral part of their school program?
2) How much time is allocated to learn mathematics and science in the participating elementary schools at fourth grade?
3) What are fourth grade elementary student perceptions of their science and mathematics instruction and learning?
4) What are teacher and principal perceptions of fourth grade science and mathematics instruction in their school?
5) What is the relationship between instructional time and science and mathematics achievement of fourth grade students?

Hypothesis:

The null hypothesis is there is no relationship between instructional time (time on task) and student achievement of fourth grade students in the areas of science and mathematics. The goal was to determine if there is a correlation between the two variables.

Significance

Few studies have been conducted on time spent on mathematics and specifically, science in elementary schools and its relationships to student achievement. State educational agencies and local educational agencies that receive federal funding to support schools designated as low achieving are mandated to report how time is allocated regarding instructional programming in their schools. Student performance in both science and mathematics is a factor in the accountability system for the schools studied in addition to reading achievement levels. The intent of the study was to show the role elementary schools can play in the development of students in STEM, specifically science and mathematics. Additionally, the study supports a body of researchers and national organizations who advocate the nurturing of U.S. students in science and mathematics to develop a 21st century technologically advanced society by ensuring equitable exposure to opportunities to learn both science and mathematics as early as possible in a child’s education.

Operational Definition of Terms

Allocated time: number of minutes scheduled for science and mathematics instruction.

Asynchronous Learning**:** A flexible learning opportunity that does not require teacher led face to face instruction with student learning. Students work independently with the teacher as a facilitator with technology infused instruction.

COVID-19: Acronym for the Coronavirus 19 Pandemic outbreak across the U.S. and other countries.

ESSA: Every Student Succeed Act (2015) put in effect by President Barak Obama is a reincorporation of ESEA Act of 1965 and an amendment to the No Child Left Behind.

Act (2001): ESSA focuses on providing federal funding to improve school's accountability regardless of race or income specifically targeting support for college and career readiness.

Instructional Time: the actual number of minutes allocated to a specific content in a school's instructional program during the school day.

MAP-refers to measures of academic progress and is a metric associated with the

NAEP-National Assessment Educational Progress: is the entity responsible for assessing national achievement of U.S. students in core areas of reading, mathematics, science, and social science at specific grade levels.

NCLB-No Child Left Behind Act (2001): an act by President George W. Bush that is intended to strengthen elementary and secondary school accountability in reading and mathematics. Specifically, to receive Federal funding (Title 1) students in public schools were to be reading at grade level by end of grade three.

NWEA (Northwest Evaluation Association): is the organization responsible for creating State & Local benchmark assessments in a Midwestern State. NWEA provides assessments in the areas of reading, mathematics, and science.

OECD (Organization for Economic Cooperation of Development): OECD is the organization that stores and publishes data for Programme for International Student Assessment (PISA).

Perceptions-thoughts beliefs, and feelings about persons, situations, and events (Schunk & Meece, 1986).

PISA (Programme for International Student Assessment): OECD Assessment for international students that measures 15-year old's ability to use and apply reading, mathematics, and science in real world contexts.

Principal perceptions: building level administrator attitudes towards their support and teaching and learning of teachers and students in mathematics and science.

Remote Learning: as per a midwestern state is learning that takes place outside of the traditional classroom using other platforms such as Google meet, Zoom, virtual classrooms, and telephone conferences. Remote learning can be real time or flexible time infusing technology.

STEM: Acronym for Science, Technology, Engineering and Mathematics

Student perceptions: student attitudes towards their daily mathematics and science instruction.

Synchronous Learning: real time face to face virtual instruction. The instruction is teacher led requiring the teacher to provide direct and explicit instruction where students are actively engaged in the lesson. Students and teachers are interacting throughout the class lesson.

Teacher Perceptions: teacher attitudes held toward their teaching practices and student learning of mathematics and science instruction.

Time on task: the actual number of minutes students were observed engaged in a learning activity or academic exchange of communication between student and teacher asynchronous or synchronous during mathematics science instruction.

TIMMS (Trends in International and Mathematics Science Study):

Limitations

The study has the following limitations:

1. The study population was not a comprehensive, unbiased randomly selected sample. All student participant NWEA data came from one school district in an urban area in a Midwestern. This limitation was due to a convenience sample & population during the pandemic.
2. Remote learning conditions reduced the number of instructional minutes and limited student and teacher interactions. This limitation occurred to accommodate

modifications of instructional learning time from five hours of in person instruction to two hours of virtual instruction.

3. Location threat was possible as during the administering of the NWEA MAP students were taking the assessments in various locations within the two schools studied and times based on a district scheduled assessment window. This limitation was evident in reliability checks of student data. Remote learning conditions mandated that all student testing opportunities occurred virtually.
4. Participation of student and staff perception surveys was voluntary. This limited the number of surveys returned and student participation. Recruitment of participants during the pandemic was challenging for a myriad of factors to include teachers, students, and parents reluctant to participate due to the conditions of learning which dictated only online completion and submission of documents to include letters of consent.
5. The inability to conduct in person observations and in person support during data collection in a traditional classroom space due to COVID-19 and remote learning conditions was a limitation. In person observations were not allowed due to the pandemic as all learning was 100% remote learning for teachers and students who were in their separate spaces/person living arrangements.
6. Varied reading abilities of students might impact survey data. Reading proficiency levels based on data showed that reading abilities for some students might have been a challenge to comprehension and completion of survey questions.
7. Type of elementary science instruction such as departmentalized or self-contained, asynchronous, and/or synchronous) varied from school to school. During the study

both school schedules depicted departmentalized instruction which became a constant variable. However, the type of facilitation of instruction (asynchronous vs. synchronous) did vary from school to school. This factor limited opportunities to learn based on the implementation strategy chosen to teach students during the allotted time for science and/ or mathematics.

8. Type of strategies to support student engagement and time on task was limited and varied from school to school due to remote learning conditions. Teaching strategies and student activities (time on task) which were afforded to students varied. This is based on survey data of student opportunities.

Delimitations

1. The survey window might have been perceived as a delimitation to participants. It allowed participants flexibility in taking the survey. The staff survey window was extended over a three-day period which allowed teachers 24-hour access to the survey during completion.
2. Online access allowed a more user-friendly approach to taking the surveys and reduced biases during the surveys. The online access to the surveys removed the need for printing materials, distribution, and return issues. The survey platform used was selected over Qualtrics and survey monkey as the google form platform was a technology resource that teachers were already using and familiar with the formatting.
3. Activities and task for participants were minimized as participation might be perceived as overwhelming due to teacher and student learning in a non-traditional space and classroom setting. All instruments and data collection tools

were either via survey or self-report tools where the staff had the ability to collect their own data for the measures in the study.

4. Instructional time prior to testing was calibrated. Instructional time prior to testing varied due to school-based schedules created inside a testing window. Due to the autonomy of school-based assessment schedules the mean was used to calculate the number of weeks of instructional time.

Reflection

The chaos theory is a perspective used in the natural sciences which emerged from the butterfly effect and has been applied to education. It is the assumption that through all the unknowns a complex, unexpected problem will be and can be solved. (Norman, 2011) This assumption was implied in this study as the unpredictable nature of the events that took place during the pandemic impacted the teaching and learning processes of educators across the U.S.A. The new shifts in learning during the pandemic not only affected the timeframe of the study, but how the study was conducted. The Coronavirus 19 pandemic swooped through the education system like a whirlwind. The natural environment to educate students changed the entire dynamics of teaching and learning. Plans for recruitment of teachers and preliminary procedures to conduct the study changed overnight. In addition, my role changed during the pandemic transitioning from a building leader to a district leader responsible for supporting teachers who were expected to educate students from their living rooms and other personal spaces. The guiding question for me as a district science leader was, what are the resources available for teachers to teach students science at home? I do not know how this question was answered for many schools and districts, but I do know that for this midwestern school district the first thing that came to mind is how this can be done equitably for science learning in an urban setting with children who reside in a community with school percentages of free and reduced lunch of more than 95%. Science is not like mathematics or reading when it comes to the ability to accessibility of tangible resources outside of traditional learning spaces. Laboratory equipment although essential is a safety concern during in person learning and is an even greater risk when trying to facilitate this type of learning at home. My thought, how do we start and where do we start. With these thoughts in mind, I had to cultivate relationships with teachers and lean on my own pedagogical knowledge of what will most likely work best for the student and the teacher when considering curriculum resources and support. Trust in teacher knowledge and technological skills was central. Adaptability to virtual classrooms as the platform of pedagogy and monitoring learning was vital. In the past evaluation of resources that could transition to at home learning environments was something that I never considered for the majority but only for a few given instances. Through it all, I found the most useful resource I could provide to teachers was the ability to manipulate the curriculum to allow more time for students to learn rather than more time for teachers to teach.

CHAPTER 2
LITERATURE REVIEW

The U.S. Department of Education (1991) stated that U.S students would be "first in the nation" in mathematics and science achievement. Branscomb and Johnson (1992) refuted the idea of success for U.S.A. students based on research conducted showing little science being taught in elementary schools. While current statistics have shown that U.S.A students at the fourth-grade level are outperforming their peers internationally in mathematics and science, many minority students in urban settings are not contributing to this success based on their low academic performance in science and mathematics (NAEP, 2019).

Despite the efforts of setting National Standards for mathematics and science, issues concerning exposure of U.S. students at early ages continues to plague society today (Kane, 1994). During my personal collaborations with teachers and administrative leaders across a midwestern state to transform national science standards to expectations for state assessments it was found through conversations that many districts in a midwestern state experienced similar challenges of teachers not exposing students to science at the primary grade levels. For some U.S.A. schools, students are still not performing in science as nationally expected due to a focus on reading and mathematics, and other factors impacting the instructional school day such as social emotional learning that are meant to ensure the needs of the whole child are met (NCLB, 2001). The statistics provided after the 1983 "Nation at Risk" findings revealed a discouraging future for students and the ability of U.S.A. teachers in urban settings to provide quality mathematics and science learning experiences to students in K-12 systems. (National

Commission of Excellence, 1983) Branscomb and Johnson (1992) revealed the following: “at the elementary level only 5% of teachers were trained to teach science, at the secondary level 60% of math teachers and 40% of science teachers did not have degrees in the subjects they taught” (p.96).

Current practices in the district for this research is that elementary school teachers are not required to be specialized in the areas of mathematics or science. Most often teachers are placed in upper elementary classrooms based on their level of interest and pedagogy skills rather than expertise in the subject area. However, secondary teachers of mathematics and science must have degrees in these content areas. While the statistics are unknown for math and science degrees at the elementary level in this state, the lack of teacher preparedness for content knowledge in science and mathematics is a possible factor for low student achievement as to whether science or mathematics is taught and for how long in reference to the amount of time given to these areas of instruction.

Norman (1991) takes a similar approach to ideology regarding mathematics and science reform as Branscomb and Johnson (1992). Norman refers to the Carnegie Commission Report led by Branscomb stating that the federal government did not adequately invest in science and mathematics reform in U.S. schools. However, he stated the deficiencies in math and science achievement and readiness of students to make U.S.A. top in the areas of mathematics and science primarily rest at the federal level for not properly funding initiatives to support research and growth in those areas (Norman, 1991). Today the U.S.A. Department of Education provides monetary resources to school districts in a fund called Title 1 (ESEA, 1965). This funding has been made available to high need school districts, which have students or schools considered to be disadvantaged based on census data. This funding is provided to support students who are predicted to be at risk in academic performance. This funding source is more advantageous to urban communities because unlike prior funds, such as SIG funding (school improvement grants) the data necessary to best meet the needs of students are based on geographic locale vs. academic data, which can make the grants more equitable.

U.S.A. Science and Mathematics Achievement

In 2019, U.S.A. participated in the Trends in International Mathematics and Science Study (TIMSS) national assessment for grades four and eight along with 60 other countries. The TIMSS assessment is given every four years and shows a comparison of how the U.S.A. students compare to their world peers in these subject areas. Results from the TIMSS 2019 assessment showed U.S.A. students ranked 18 among the other countries in mathematics and ranked 14 at grade level four in science. Countries ranking higher than the United States in mathematics includes Hong Kong, Singapore, Republic of Korea, Japan, Northern Ireland, Chinese Taipei, and the Russian Federation. The importance of these comparisons is to provide another perspective of the importance of preparing U.S.A students and providing early learning experiences in science and mathematics to help support progression and innovation in the U.S.A in the areas of economics requiring science and mathematics. Although several countries ranked higher in 2015, U.S.A. students showed considerable progress over the past 10 years (TIMMS, 2015). On the 2015 assessment 14% of U.S.A. fourth graders scored advanced on the math benchmark and from the period of 1995 to 2015 there was a significant increase in math performance scores. Science results from the 2015 TIMSS assessment showed that U.S.A. fourth grade students outperformed students in 38 other countries. The importance of these comparisons is to provide another perspective of the importance of preparing U.S.A students for early learning experiences in science and mathematics to help the U.S.A in world economics maintain a position of leadership.

However, within the U.S.A. public school system, disparities of student performance still exist particularly in urban communities of low socioeconomic status. National Assessment of Educational Progress (NAEP) data results in 2019 showed that 37 percent of U.S.A. fourth grades students were proficient in science. NAEP data revealed gaps among black student and other groups who were tested. Only 21% of black students scored proficient in science as compared to 50% of white students scoring proficient. Results from the 2019 NAEP data showed 41 percent of fourth grade students were proficient in mathematics, but some minority student groups scored significantly lower than non-minority groups. According to 2019 NAEP data proficiency cut scores for science was 167 and for mathematics 249. National School Lunch Program data reflected those students eligible for school lunches in science and mathematics were below the national average mean scores in those areas. Table 4 shows the differences in the scores of students who were eligible versus students who were not eligible for free and reduced lunch. Differences of students not eligible for both mathematics and science are well above 10 points and those students not eligible were either proficient or near proficiency for science and/or mathematics. Figure 3 shows the NAEP scale scores for the midwestern region in which the study was conducted.

Table 4

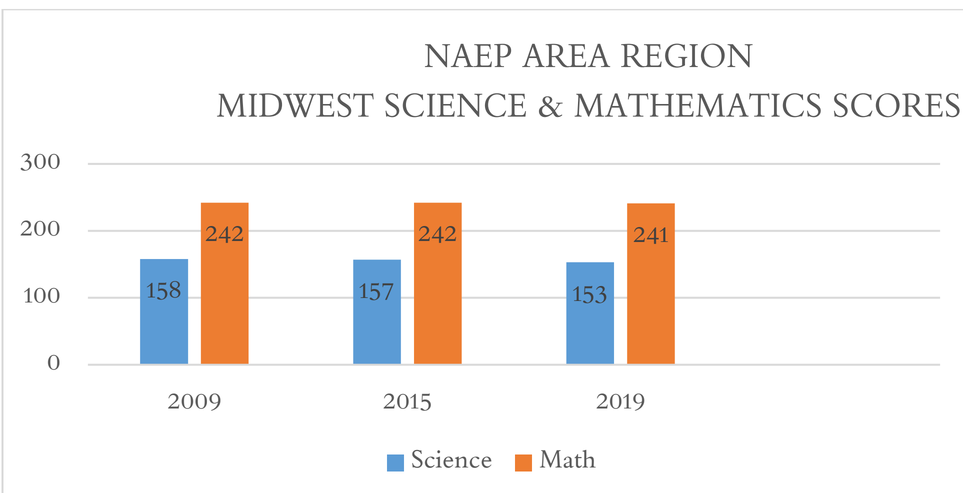
NAEP Science and Mathematics Scores of Students Eligible and Not Eligible for National School Lunch Program

2019 NAEP NSLP Mathematics and Science Scores				2019 NAEP Cut Scores		
	EL NSLP	NEL NSLP		Achievement Levels	Science	Mathematics
State /Math	226	249		Advanced	224	282
Nation/Math	229	253		Proficient	167	249
Nation/Science	137	166		Basic	131	214

Note: Findings from the data shows that students in school lunch programs score on average lower than students on no lunch program. EL is eligible and NEL is not eligible for the National School Lunch Program. Adapted from NAEP 2019.

Figure 2

NAEP Area Region Science and Mathematics Scores



Note: NAEP 2019 Scale scores are for mathematics and science for fourth graders of a midwestern state. Source: NAEP 2019

The science proficiency scale is 0-300 and the math proficiency scale is 0-500. All scores for the region are below 300. Both mathematics and science scores for the midwestern region based on Table 4 cut scores are below the proficient achievement level. These scores reflect the achievement level mean score for all 4th graders who tested on the 2019 NAEP assessment. Trends show that the science scores decreased over a 3-year testing period and the math scores were stagnate for two testing periods with a 1 point decrease the third year reported.

The overall 2019 NAEP data for elementary fourth grade students in the U.S.A. have shown improvement in science and math performance, the Programme for International Student Assessment 2018 results show that U.S.A. student levels of progression who tested at age 15 in reading, mathematics, and science did not reveal significant progress. Fifteen-year-old students in the U.S.A. scored above the Organization for Economic Cooperation of Development (OECD) average in reading and science but below the average in mathematics. This below average on another assessment raises an awareness as to the important role of K-12 science and mathematics educators play in ensuring opportunities to learn and exposure of those content areas, in an appropriate way to students. The PISA assessment is also an assessment geared towards International Baccalaureate (IB) which tests students who are on target for advanced students in science and mathematics. Results from the PISA assessment was like NAEP regarding achievement based on socioeconomic data, concluding that this level of achievement exists at both the national and international level.

Resource Time Allocation

To address some of the effects of the No Child Left Behind act which provided a greater emphasis and accountability of student learning in reading and mathematics the National Research Council published a report titled Monitoring Progress Toward Successful K-12 STEM Education: A Nation Advancing? (NRC, 2013) This report focused on school district readiness and preparation in science and mathematics as indicators toward building programs and student skills towards science, mathematics, engineering, and technology. There are fourteen indicators mentioned in the report. Indicator two (NRC, 2013) measured time allocated to science in grades K-5, but time was only measured as how much time was allotted to science per week. Other factors such as time of teaching science or actual student time on task was not measured or defined. The National Research Council suggested that the amount of time to teach science at the elementary level is of importance because student experiences in science prior to middle school can have an impact on career readiness (NRC, 2013 pp.12-32). This reduction of time may have a greater impact on elementary students in impoverished school communities as many students in these environments have connections and exposure to formal science only during the school day.

These formal learning experiences are important to support students in making connections to how they view and experience science in their everyday lives. All students bring experiences and some form of background knowledge to how they see and live in the natural world. These formal learning opportunities often provide students clarification and tools for understanding the nature of science and integration of other subjects such as mathematics.

The Next Generation Science Standards which were adopted by 20 states and the District of Columbia in the U.S.A. (NGSS, 2013) is based on a framework that builds yearly on conceptual knowledge of four content domains (life, earth and space, physical science, and engineering, technology, and applications of science) integrated with science and engineering practices and cross cutting concepts based on prior knowledge and background learning experiences (NGSS, 2013). These national science standards along with the Common Core mathematic standards are designed in a K-12 Framework to support scaffolding of major concepts as learning progresses. Decreasing instructional time or eliminating student instruction in mathematics and science in elementary settings can lead to students missing important prerequisite content knowledge needed for success and interest in the subjects as they continue to learn science and mathematics concepts during secondary schooling. In my experience as a former secondary teacher and school principal, students who were not exposed to mathematics and science concepts before secondary schools often did not take advanced courses such as AP or pre honors when they reached high school due to a lack of interest or prior background knowledge in science needed for success.

Resource allocation in school districts is often defined as tangible resources such as textbooks, pencils, and other curriculum materials essential to lead instruction during the school day. However, many resources such as manipulatives and other hands-on materials which are very important for student engagement are often not used as planned in urban elementary settings due to other non-tangible factors such as actual time to teach and environmental factors commonly associated with socioeconomics in lesser served communities. Students and teachers must have enough time to learn and practice skills and concepts to gain a deep understanding of mathematics and science to lead towards interest in later years.

Resource Allocation in School Districts is an analysis of a study conducted in 1998 at ten British Columbia schools that explored the relationship between resource allocations and equity and excellence goals. It was concluded that in British Columbia public school systems resources were often treated as “a competition between equity, excellence, and policy split between fiscal and non-fiscal resources” (Boyd & Hartman, p. 102, 1998). Of the two types of resources, the most productive type is non-fiscal which are resources such as time, personnel, and information (Coleman, 1998). The study revealed that while British Columbia elementary fourth grade students who participated in the TIMMs mathematics and science assessment performed lower than participating U.S.A. students one common factor noted that is evident for most schools today in the U.S.A is that the non-fiscal resource of time is still a major concern affecting student learning.

Demographically it was found that communities that did not perceive cost as a primary factor for educating students, achievement levels were higher than communities of students who were tested in disadvantaged areas based on socioeconomics (NAEP, 2019). An article by Anne C. Lewis (2005) stated that students of poor countries tend to score lower than other countries. A district level meta-analysis was conducted by Boyd and Hartman on cost quality relationships in education, and the meta-analysis data concluded that schools where students were high performing did not find fiscal resources as the primary indicator for success (Boyd and Hartman, 1998). Due to the latter the use and prioritization of non-fiscal resources such as time is essential. Regardless of the economic environment time is a common factor that is not associated with tangible costs but is noted as having many challenges regarding teaching and learning. Conditions for teaching science and mathematics in urban elementary settings must extend beyond the curricula materials to address gaps associated with exposure and opportunities to learn. For this reason, time allocation is the independent variable in the research, and it was examined to determine the relationship between instructional minutes and science and mathematics achievement in elementary settings.

Rossmiller (1986) examined the relationship between the allocation and use of time in elementary school classrooms and the students' achievement scores in reading and mathematics. The focus of the study was time on task which was defined as "paying attention" and 'trying to learn" (p. 193). The notion of how time was used in the study was like the use of time as prescribed in the Carroll Model (1963). Student time on task regarding the number of instructional minutes allocated to each subject area were explored and data showed how the number of minutes allotted decreased at each grade level from an average of 209 minutes per day for third graders to 179 minutes a day for fourth graders and to 152 minutes per day for fifth graders. It was found that the reduced minutes were not due to a shortened school day but to other activities that occurred during the school day impinging on time for mathematics and science (Boyd and Hartman, 1998). The average minutes of instruction for each specific content area was not provided in the study. However, the shortened day of instruction occurs frequently in many school settings and the average number of minutes for each content area is often based on the instructional needs of the students in which the school serves especially in urban settings and disadvantaged communities where addressing the needs of the whole child need to be met prior to beginning any teaching and learning. For many school communities this phenomenon of meeting the needs of the whole child is done through social emotional support provided to students through lessons and other non-academic activities in addition to core subjects such as reading, mathematics, and science.

Student Perceptions

Lewis (2005) stated "as compared to students in high achieving countries, American students believe strongly that mathematical talent is innate, and believe less strongly that effort makes much difference (p.241)." This belief of students' mathematical ability holds true for many students I taught in my prior years as a secondary classroom science teacher. Through experiences I found that some students avoided advanced science and mathematics courses due to their belief that they did not have the required skills to successfully pass courses such as chemistry and physics, which require a substantial mathematical background. When students were asked why they felt this way regarding these courses a common answer was they were never good at mathematics and/or science and it has been that way since elementary school. Also, it was noted that many students who were high achieving in advanced science and/or mathematics courses stated they were just naturally good in those subject areas and the content was easy for them to learn.

NSTA (2018) posits that effective elementary education should be the foundation of science learning that engraves an interest and sparks enthusiasm for student interest in science for later grades. Denessen (2015) "suggests that students develop their attitudes towards science at an early age and by the age of 14 student attitudes towards science have been formed, thus impacting their future career choices" (p. 1).

The national testing age for science and mathematics is age nine, which is equivalent to the fourth-grade level in public schools in the U.S.A, and by age 14 most students in U.S.A. public school systems are entering the 9^{th} grade or their freshman year in high school. To ensure that students are equipped and exposed to science and mathematics providing students tools to support them prior to assessing is important for student self-efficacy and confidence in these subject areas. Providing students hands on experiences and real-life applications to science and mathematics PK to grade three is essential to build background knowledge and formulate content-based understanding of these subjects by the age of nine or the fourth-grade level. By this age level in accordance with theorists such as Piaget this is the concrete operational stage where students can solve problems (Clark, 1996).

It is my belief that student perceptions and attitudes toward science at early ages can be perceived from a lens of motivation impacted by time. Formerly my prediction regarding student perceptions was that perceptions were probably influenced based on the duration of a stimulus, time. The length of time during which student learners experience science and mathematics is the predominant factor impacting time on task or how students can use the time allotted. Time is defined by two aspects: 1) instructional minutes allocated for mathematics and science and 2) exposure to mathematics and science as it pertains to time on task regarding student learning opportunities.

Teacher Perceptions

Teacher-Student Relationship Quality known as TSRQ was documented in a study by Chestnut (2020) reviewed the high and low-quality characteristics of relationships between students and teachers. Specifically looking at two dynamics of the relationships paired as closeness or conflict. The closeness of the student-teacher relationship proved correlated with warm and positive feelings affecting attitudes of both the student and teacher. The dynamics of conflict between the student and teacher subject relationship tended to have negative student engagement and interactions. These interactions can influence the communication between student and teacher and impact either positive or negative student outcomes of achievement and social behaviors and attitudes.

Smith & Nadelson (2017) stated that self-efficacy is a measure of confidence a teacher has for teaching a particular subject and that it influences teacher instruction (p.195). The authors commented that teachers at elementary levels might intentionally avoid teaching science if perceived that they are not knowledgeable in the subject matter.

While math learning is a focus in many schools, minutes of instruction considerably exceeds science learning in many elementary settings. The results in the study revealed that teacher lack of confidence in their abilities to adequately prepare students in science and math is contributed to their lack of content knowledge (Callahan, Dance, Hay, Nadelson, Pfiester, & Pyke, 2013). In many U.S.A. public-school systems, elementary teachers are tasked with teaching every subject or at least two subjects per day depending on teacher schedules. Building teacher confidence in subject matter can be challenging for some teachers depending on their subject matter interest and preference. According to social cognitive learning theories, children learn by modeling behaviors and expectations of their teachers who may unintentionally instill their own values and beliefs of teaching in their students (Denessen, Hasselman, Louws, & Voss, 2015).

Teacher perceptions and beliefs are of utmost importance when teaching in areas such as science and mathematics as these two subjects are driven by application or a hands-on approach which requires adequate teacher content knowledge and pedagogical skills plus enough class time to adequately apply these skills. Social cognitive theories cite that teacher perceptions and attitudes shapes student thinking and abilities as the students observe and listen to comments of the teachers (Denessen, et. al 2015). Positive beliefs of student abilities as well as negative beliefs of student abilities by teachers can impose student self-fulfilling prophecies regarding success on daily activities and assessments.

Cezernak (2011) cited the Theory of Planned Behavior in a study that focused on elementary teacher beliefs regarding assessing students. Most interestingly the study stated that, “attitudes become action agendas, that guide decisions and behaviors (p.114). The latter statement is in my perception very relevant at all levels of education but can be exceptionally powerful at the elementary levels and teacher preparation. Guiding teacher beliefs to raise awareness of the role they play in ensuring science and mathematics instruction is provided during their day can impact their focus on daily lessons thus creating action agendas for planned instruction in those areas.

Reflection

Researching literature for this study during the pandemic was my first experience of solely depending on virtual and online methods to secure materials. Although this service has been offered at the university level for more than a decade, knowledge that this is the only venue was an eye-opening experience as to pedagogies and strategies teachers and students must acquire or know to conduct research for classroom experiences. My Boolean searches expanded from the initial search of achievement data to teacher and student attitudes regarding science. Achievement data for science and mathematics was researched based on historical knowledge of science and mathematics achievement to more current knowledge and data sets. I chose to take a more wholistic approach to my view on assessment achievement. This view was from the lens of the larger picture to the smaller picture of science and mathematics achievement or vice versa. The NWEA assessment assesses students at the district and state level and is used as a district benchmark in science and mathematics. The NAEP assessment is used at the national level for science and mathematics, and TIMMS assessment is used at the international level for science and mathematics. Lastly, the PISA assessment is used for international students focusing on literacy in science and mathematics. These data sets allowed for horizontal views of fourth grade science and mathematics experiences for fourth grade students at each level of performance assessment. The goal was to provide insight to preparation for science and mathematics as it relates to 1) global economies 2) college and career readiness and 3) long term impacts of science literacy when students are tested at older ages.

Through my own learning experiences as a science teacher, teacher and student attitudes towards mathematics and science heavily impacts learning and teaching of these concept areas. In my early practices as a science teacher, it was found that topics of interest to me were taught with passion and contentment. Those topics were easier to convey to students which I equated to my content knowledge being easier to adapt to various pedagogies to support students in mastery of concepts. It was interesting to read and view other perceptions of mathematics and science teaching, and to notice the common theme that teacher perceptions often influence student interest and perceptions in these subject areas as well.

As a science teacher leader, district science leader, and building leader I reflected on various observations and past experiences coupled with the nuances of the pandemic and noticed that perceptions of science and mathematics were not perceived equally at the various levels of learning. It is my assumption that this is due not only to content knowledge but to the amount of time actually allocated to teach and learn the subjects. It was quite surprising to find that there is limited research on time allocation for both content areas (science and mathematics) at the elementary levels.

CHAPTER 3
METHODOLGY

The study and data collection were conducted during the 2020-21 school year amid a pandemic. COVID-19 is a coronavirus that circulated globally and widespread throughout the United States of America. Due to the contagiousness and infectious stages of the virus the pandemic set a tone for a new wave of educating K-12 students in the U.S.A. Many schools and school districts modified how they teach and what they teach based upon general guidelines provided by the CDC and state and local education agencies.

The research method and procedures used to explore the relationship of the number of instructional minutes and student performance of fourth grade students in the areas of science and mathematics are described in this chapter. The chapter includes preliminary procedures, the research design, instruments, sample, data collection procedures and statistical analysis that was conducted during the study. A quantitative approach was used to answer the research questions and SSPS was used for the data analysis.

Preliminary Procedures

Preparation began with a review of relevant literature on state and local assessments, state and local policies and procedures regarding instructional minutes of instruction for academic core areas, specifically science and mathematics. State statistical research was conducted on national norms of science and mathematics achievement to provide targets for assessment data collected. No targets were set forth in the midwestern district for 2020 but 2019 targets were available as well as a proficiency target index for science, reading, and mathematics.

During the time of the study the participating schools in an urban school district were at a level of full remote learning which means teachers and students were engaged 100% via virtual instruction. Conversations via email and telephone were provided to building and district leaders prior to any surveying and data collection to determine the best approach for data collection and minimize any undue stress or biases during the data collection period or virtual visits to classrooms. Based on conversations with building leaders the researcher contacted teachers and provided an overview of required visits, surveys, and answered any questions relating to the study. Google meetings and/or telephone conversation were scheduled to allow teachers to gain clarification prior to participation. Consent forms were emailed to all participants (teachers, building leaders, and students with parental consent) who agreed to informal unstructured interviews, completion of surveys, and any other instruments required to complete the study. Due to the limitation of type of instruction (remote learning) during the pandemic only teacher and administrative perceptions were explored as it relates to achievement data and school readiness perceptions for academic success in these areas. Student volunteer survey participation was not at a level to produce significant data for the study during the pandemic.

Demographics of School District and School Community

The two participating elementary schools are in one urban school district located in a Midwestern state. The school district was approximately 5,735 students. The district is considered as a high poverty school district with 95.9% of student families designated as low income. District student population is as follows: 97.6% Black, 1.4 % Hispanic, 0.4% White, 0.4% two or more races and 0.1% American Indian. Attendance rate for the school district is 85.6 percent. School demographics regarding enrollment vary from school to school. The highest elementary school enrollment in the district is 444 students and the lowest school enrollment is 370 students. Total number of fourth grade students enrolled in the district is 346. The population of fourth grade student at schools participating in the study is 151 which is 43% of fourth grade students in the district which is more than a third of the district students who can test at the local, state, and national levels in science and mathematics. Each school is situated as a neighborhood school. However, students can transition between schools in the district on a case-by-case basis or if it is found in the best interest of the student and family not to attend their neighborhood school. Schools in the study are referenced alphabetically as school A & B in the research and analysis. School A student population is 431students with 83 fourth grade students, and school B student population is 323 students with 77 fourth grade students.

Research Design

A quantitative approach was used to describe two different cases (elementary schools) to support a correlational research design. The purpose of the design is to "clarify an understanding of important phenomena" (Frankel & Wallen 2003, p.338). The phenomena examined was the amount of instructional time allocated reported as time on task and its relationship with science and mathematics student achievement. Other variables in the research are teacher and principal perceptions of science and mathematics teaching and student learning. Due to low participation student perception data was not collected. Additional instruments to support science and mathematics learning include a researcher created self-report time on task instrument and a school readiness self-report instrument for the school program preparation in mathematics and science. The impact of this research design is to provide a better lens for school districts and schools to best allocate the resource of time to support early opportunities for science and mathematics learning that will positively impact student achievement and student learning as evidenced by district assessments.

Sample

Initial anticipated population was 208 fourth grade students, six building principals, and six teachers from three school sites in one midwestern urban school district. Due to the COVID-19 pandemic and remote learning conditions the population was narrowed to two school sites, four building leaders and four teachers with a total of 151 students. Three building leaders and two teacher volunteers participated in the study. A purposeful targeted sample was used compiling secondary assessment data for 112 fourth grade students in the study. School A secondary data consisted of 59 student participants and School B data consisted of 53 participating students. All student participants reside in areas for one of the two neighborhood schools which are within seven miles of each other.

The recruitment process consisted of an email invitation to all fourth-grade teachers and building leaders. Two teachers, and three building leaders agreed to participate in the study. One teacher from each participating school volunteered which provided 50% of fourth grade staff at each school site. School leaders consisted of one building principal from School A which is 50% of the school leadership team and two building leaders from School B which is 100% of the school leadership team.

Consent forms were emailed to all participants who agreed to participate in the research. 100% of consent forms were received from all consenting adult participants. Google meets were scheduled to provide specific details and to answer any questions of teachers and administrators. Telephone conferences were made available to all participants who preferred an alternate to virtual meetings.

Instruments

There were six instruments used in the study: two self-report tools (one for time on task and another to reflect school readiness of the science and mathematics programs), and four surveys consisting of the following: teacher science survey, teacher mathematics survey, building leader/principal science survey and a building leader/principal mathematics survey. All survey instruments were provided to teachers via email and raw data on surveys was collected via google form summary reports. The school readiness tool was sent via email and an informal telephone interview was held to support clarification and recording of answers. Descriptive statistics were used for data analysis for all instruments.

<u>Question 1:</u>

To answer question one the school science and mathematics readiness tool was adapted from the Friday Institute North Carolina STEM Progress Report and covers five domains with each domain having four to five key elements. Identified key elements were to support school wide practice vs. district wide practices. The following areas are identified and scored as core components for mathematics and science integration: 1) student opportunities, 2) classroom environments, 3) learning connected to college and career readiness, 4) school culture, and 5) community connections. In 2011, the National

Resource Council developed a K-12 STEM indicator system. These indicators were released in a report titled Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics which describes the components of successful science, technology, engineering, and mathematics (STEM) education (National Research Council [NRC] 2011). There are fourteen indicators and nine of the indicators are related to mathematics and science school readiness. The fourteen NRC indicators are categorized by supporting one of three foci: funding and policy, teacher capacity, and accessibility of quality science and mathematics learning for STEM readiness. Six of the fourteen indicators are considered priority. Of the six priority indicators, the first two are directly associated with time. The K-12 indicators were used as a resource and reference to support alignment of the science and mathematics readiness tool to federal initiatives which require artifacts and evidence to support STEM focused schools or schools focusing on science and mathematics as their core curriculum programs. See Appendix J.

The science and mathematics readiness tool (Appendix A) was used to collect data to answer question one to determine the degree of readiness for the science and mathematics as it relates to the schools fourth grade programs. Five guiding questions were developed by the researcher to support clarity for participants during the data collection for the school readiness tool. Initial communication began with a request for a telephone conference and/or google meet to collect the data. All respondents requested telephone conferences.

Each school leader participated in a telephone conference to self-assess their schools' program for mathematics and science readiness. School leaders were provided the tool for review prior to the telephone conference. Each structured interview included the same core clarifying questions (Table 5) which were asked before the school leader provided a rating of their program in each area of the science and mathematics tool based on the ratings of Early-1, Developing 2, Prepared 3, or Model 4. (Friday Institute, 2019) Prior to each section the guiding question was asked, and the researcher recorded the data on the data collection tool.

Schools were identified as Schools A and B. The school readiness tool checklist gauged practices and processes for the level of progression of readiness for science and math learning at the elementary level. The self-report tool was emailed to building leaders of schools A and B. Three out of four building leaders participated which is a 75% response rate.

Table 5

Science and Mathematics Readiness Tool Guiding Questions

Science and Mathematics Readiness Progress Tool Section Titles	Guiding Questions Progress Tool
Student Opportunities	How often/predominantly have you seen specifically on lesson plans or observed?
Classroom Environment	Have you noted this on a lesson plan or observation?
School Structures	Is this a practice (PLCs or Scheduling)?
School Culture	Have you noted this in google classroom or observed in a classroom?
Community Connections	Have you noted this in the field or virtual?

SPSS was used to provide descriptive statistics to tabulate the mean score of readiness for each school. The measure used was ordinal.

Other information used to support the study were district and state policies and protocols and school master schedules. District policies and state protocols were retrieved via public school and state educational websites. The information was used to guide and inform the amount of time that is expected for student instruction in mathematics and science in elementary school settings. School master schedules were requested by each participating building principal via email and were used to determine the actual allocated amount of instructional time for fourth grade mathematics and science in the participating schools.

Question 2:

Question two addressed the independent variable which is the phenomenon of time. A time on task science and a mathematics teacher Self-Report tool (Appendix G) was used to answer question two. The self-reporting tool was designed to collect science and mathematics instruction daily over a 6-week period. Assessment of students are encouraged for every two to six weeks of instruction. Six weeks of instruction is the current curriculum practice for the maximum time of instruction provided to students prior to any testing for the research locale.

The self-report tool was emailed to teachers. The instructions to complete the tool were provided to all participants individually via google meet and follow up was provided through telephone conversations. Teachers could share this information on a weekly basis indicating number of actual instructional minutes provided daily any time during a six-week window. 100% of respondents returned the self-report tool. Descriptive statistics were used to analyze the mean of time allocations for school A and B using SPSS.

Question 3:

The student subject instrument consisted of a 49-question survey exploring student perceptions of science and mathematics learning (See Appendix D). The student perception survey has 34 Likert scaled questions, five questions pertaining to student perception of teacher practices and seven questions on student perceptions of engagement activities of science and mathematics during class.

The student perception survey instrument questions foci are the phenomena of time to learn, opportunities to learn, and their account or event (phenomenon) of science and mathematics instruction received. The surveys include questions to gauge student background information of their knowledge of various careers or jobs in science and/or mathematics. The surveys were designed to complete online or paper pencil in one classroom period for science and one classroom period for mathematics. The surveys were created by the researcher, modified, and adapted from the Friday Institute and NAEP mathematics and science questionnaire.

Initial communication for student participation was through building leadership and then teacher participation. A google meet was scheduled via email to participating teachers to allow the researcher to recruit and explain the research and survey process to students. Each participating teacher who agreed to the study allowed the researcher to meet with students virtually through a google class where a question-and-answer session was allowed to include consent form information. Due to Covid-19 and remote learning student participation in the study was a limitation.

Question 4

The teacher online instruments (Appendix D&F) consisted of two 32-question surveys related to teacher perceptions and practices of science and mathematics learning. Each survey consists of 32 Likert scale questions. The administrator science and mathematics perception survey instruments (Appendix B&C) consisted of 32 questions and gauges school leadership practices and initiatives for promoting science and mathematics learning. The administrator survey consists of a total of 32 questions: 31 Likert scale questions and one open ended question related to time to teach science and mathematics

The online surveys (Appendix B&C) were shared with teachers and principals through google platform as google forms. Survey instructions were provided via email, telephone conversations, and/or google meet depending on participant preference and needs for clarity for completion. Participants could access surveys during a five-day window at their convenience. Once surveys were started, they had to be completed for valid submission. Only one mathematics and science survey were allowed for each participant. All participants in the study completed the surveys for a 100% respondent rate. Descriptive statistics using SPSS were used for data analysis. Raw data was compiled via google summary reports.

Question 5:

A secondary data source the NWEA assessment and the Carrol Model of Learning Formula which was modified by the researcher was used to answer question five to explore the relationship between time and student achievement. The NWEA assessment is a midwestern state and local school district benchmark that is administered to students three times per year. The NWEA assessment content is aligned to the state and national standards addressing critical domains of Common Core mathematics and the Next Generation Science Standards. NWEA data compiled from students of teachers who participated in the study during the data collection period. Science and mathematics NWEA assessment data was requested from district leaders who provided Fall NWEA mathematics and science fourth grade assessment data for SY 19-20 and 20-21. For purposes of this study only SY Fall 20-21 school data was used for participating schools A and B. Data was disaggregated for students who took the assessments in classes of teachers who participated in the study. All student data collected and used in the study had a reliability ratio approved by the participating mid-western district assessment office due to extenuating testing environments and protocols during COVID 19.

SPSS was used for descriptive analysis and t-test of student data. To support the Common Rule school identities were kept anonymous. Student and staff information were translated from secondary data in the forms of tables removing all identifiable information prior to analyses.

Reflection

The methodology used during the study is the one aspect of the study that was most impacted during COVID 19. Every planned strategy was modified to support the shift in conditions of learning from in person learning to virtual instruction. During the research my role changed from a school leader back to a district leader. So, recruitment strategies of teachers, staff, and students was a different perspective for all involved based on a role change and a shift in duties to now ensure the instructional preparation for teaching science was intact. This is where I viewed the theoretical approach of the Chaos

Theory (Norman, 2011) in my own personal accounts of preparing teachers for their role to support remote learning practices and protocols. My consult to teachers and myself was not only a reminder but a teachable moment that this is a great opportunity to explain to students at very early years and specifically at secondary grades that you are providing an enrichment opportunity for all students to think and act like college students. I explained to teachers to share with students, now this is what college students do daily. You are now allowing them to think and act like the big kids at very early grade levels.

Any method I wanted to use for recruitment of volunteers such as having a conversation with teachers and students to explain the details of the project and what to expect as a participant in the research was narrowed down to only virtual communication experiences such as Google Meets, Zoom, email, or phone conversations. All the latter were used except for zoom as the district platform for communication was Google Meet so this venue was a more convenient approach lending accessibility for all. The google platform wasn't anything new or additional, but something everyone involved was currently using and familiar. Documents such as consent forms and assent forms were now at the mercy of digital programs such as KAMI and scans. The length of the documents became a limitation for some as the scrolling of pages became overwhelming for some teachers, parents, and students. Although the forms were simple in content the complexity of the look in my perception was a deterrent to complete the forms. The delimiting factor to counteract the intensity of reading and completing consent documents was emphasized during the Google meet on how their participation was strictly anonymous and as a volunteer at any point during the study they could discontinue their participation with no adverse effects or loss of professional collaborative relationships.

Unexpectedly, of those who agreed to participate their participation was at 100% in a time of a complexity for educating students.

The recruitment and data collection occurred in the timeframe of March 2019 thru September 2020, and the primary tool of communication was virtual. The technology issues in the district during that period were minimal as far as collaboration and data collection. For all stakeholders during the pandemic the latter sometimes changed suddenly so adaptability throughout the study was required. As a researcher learning how to Google meet, chat, and teleconference was critical, and the resources were vital to the methodology. Many students in disadvantaged communities such as the area where the data was collected did not have accessibility to internet or wi-fi. The latter situation eliminated some potential participants due to inaccessibility. Recruitment of students required the researcher to gain permissions to enter google classrooms and meet with students and parents virtually. This task was done through advisement of building leaders who are accountable for privacy and rights of staff and students when research studies are conducted at their individual sites. Teachers were given full autonomy from building leaders on how they chose to allow the researcher to access students. Preplanning meetings were conducted with school leaders and the plans to recruit and collect data from all participants were then executed. Unfortunately, the limitation of in person explanations to students and parents played a critical role in gaining student participation which resulted in numbers lower than a significant sample size to pursue student perception data from surveys. Due to this factor no data was collected for research question three, which excluded student voice in the study.

CHAPTER 4
RESULTS

Chapter 4 presents the findings and statistical analysis of the results of the data collection and information gathered from other sources to answer the research questions. Descriptive statistics provided in figures and tables were created using SPSS. Each question and instrument used for data collection is described in detail.

Question 1: Science and mathematics integration in school programming

Data collection and information consisted of district polices relating to mathematics and science instruction, master schedules, curriculum resources, and the building leader completion of a mathematics and science readiness tool. Curriculum policy states all grades K-8 shall provide instruction in all core areas only specifying time for reading. Sixty minutes of reading opportunity must be provided to all students K-3 who are reading below grade level (District Policy, 6.60).

State Policies and District Guidelines

During the regular school calendar year, the number of minutes allotted to each subject area is 90 minutes of mathematics instruction, 120 minutes of reading instruction, 30 minutes of science instruction and 30 minutes of social studies instruction. (District Policy 6.60) During the study all school participants were engaged in 100% remote learning and the number of minutes allocated were modified in accordance with a midwestern State Protocol and Guidelines for remote learning due to the Coronavirus 19 Pandemic for the SY 20-21 school year. The Executive Order allowed the State Superintendent of Schools to implement and address the minimum requirements of remote learning conditions set forth in a midwestern state public school system.

The District Remote Learning Plan (2020) is a document that outlined the criteria for teaching and learning remotely in core subject areas as well as extracurricular courses. The district guidelines were set forth to support science and mathematics during the pandemic and those guidelines requiring students to participate in at least 2.5 hours of instruction out of a five-hour day. Table 6 shows minimum requirements set by the district with the expectation that school elementary programs consist of at least 25 minutes science instruction, 70 minutes of mathematics instruction, and 80 minutes of ELA/reading instruction daily. The allocation of time set forth for science only reflects a difference of five minutes as it relates to science during the regular school year operating under normal conditions which requires 30 minutes of science per day. Mathematics time was reduced by 20 minutes and reading was reduced by 50 minutes less as compared to the allotted time for instruction during the regular school year.

Table 6

Instructional Minutes Guidelines Remote Learning

Grade Level	Minimum	Maximum
PK	20 minutes/day	1 hour/day
K	30 minutes/day	1 ½ hours/day
1-2	45 minutes/day	1 ½ hours/day
3-5	1 hour/day	2 hours/day
6-8	Class: 15 min/day Total: 1 ½ hours/day	Class: 30 min/day Total: 3 hours/day
9-12	Class: 20 min/day Total: 2 hours/day	Class: 45 min/day Total: 4 ½ hours day

(Table 6 p. 65 shows minimum and maximum guidelines of remote learning instruction Established in a midwestern public school district. Source: District Remote Learning Plan, 2020)

Master Schedules

School master schedules are required by the state and district to support instructional time and schedules for student learning and teaching in the core and elective courses offered to students in the district at all grade levels including prekindergarten. Remote learning master schedules were created with autonomy based on district time recommendations for instruction at each grade level (See Table 6 p. 66). Grade four students were allotted no more than two hours of engaged instruction per day and no less than one hour of engaged instruction per day. Schedules from Schools A and B were reviewed and analyzed. Time allocated to each core subject area specifically mathematics and science as evidenced in the school master schedules was calculated manually. During the study all school participants were engaged in 100% remote learning and the number of minutes allocated were modified in accordance with the midwestern State Protocol and Guidelines for remote learning due to the Covid 19 Pandemic for the SY 20-21 school year. (District Remote Learning Plan, 2020)

Master schedules submitted by each school during remote learning provided the following information: 1) number of teachers who teach mathematics and science, 2) number of classes taught, and 3) the time allotted to mathematics and science instruction. Both schools A and B allocated time to mathematics and science instruction daily as per school leaders who have autonomy to schedule instructional time of core content within the district required minutes of instruction. Master schedules are required documents evidencing instructional time for all schools in the midwestern district where the research was conducted.

Analysis

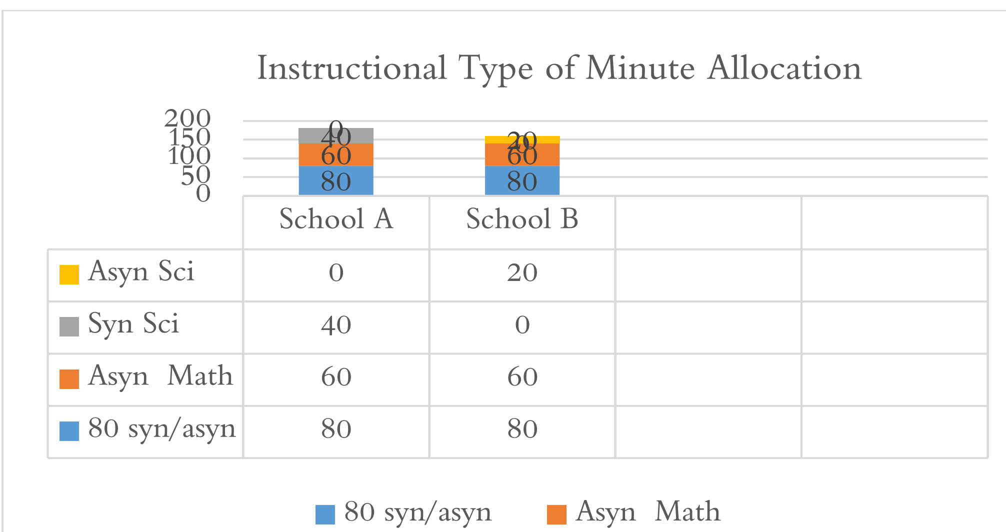
School A has a total population of 431students and 80 fourth grade students. There are two fourth grade teachers allocated to mathematics and science. Instruction is departmentalized and both teachers teach mathematics and science. One teacher participated in the study which is 50% of School A’s mathematics and science team. The master schedule reflects a remote learning schedule that allots 85 minutes of daily instruction to mathematics and 50 minutes of daily instruction allotted to science. Due to teachers teaching both mathematics and science, the minutes of instruction are separated into two sections an A group and a B group. Mathematics group A received 25 minutes of mathematics instruction and 20 minutes of science instruction and group B received 60 minutes of mathematics instruction and 30 minutes of science instruction.

School B has a total population of 427 students and 75 of those students are fourth graders. There are two teachers allocated to teaching mathematics and science. The school program of instruction is departmentalized, and both teachers teach mathematics and science. One teacher participated in the study which is 50% of the school’s mathematics and science team. The master schedule reflected a remote learning schedule that allots 140 minutes of daily instruction to mathematics and 50 minutes of daily instruction allotted to science. Due to departmentalization the minutes of instruction are separated into two sections an A group and a B group for tiered/differentiated student learning. Mathematics group A receives 80 minutes of mathematics instruction and 20 minutes of science instruction and group B receives 60 minutes of mathematics instruction and 30 minutes of science instruction. Master schedules for schools A and B reflect reading instruction (ELA) minutes which are equal to the number of mathematics minutes of instruction allocated. Schools A and B master schedules both indicated two teachers designated to teach reading, mathematics, and science at the fourth-grade levels.

Grade four students were allotted no more than 2 hours of engaged instruction per day and no less than 1 hour of engaged instruction per day. Schools A and B both provided student learning in the following content areas: mathematics, science, ELA (English language arts/reading), social studies. Master schedules for Schools A and B reflect remote learning instruction known as synchronous and asynchronous pedagogy. The figure below shows the type and number of minutes of instruction provided to mathematics and science during the study.

Figure 3

Minutes of Instruction Allocated by Type (Asynchronous & Synchronous)



Note: District protocols set forth two types of instruction (synchronous and asynchronous). Minutes allocated to each type or shown in the figure. Source school SY 20-21 master schedules.

Curriculum

All schools and personnel have access to a digital district curriculum folder which provides a scope and sequence which is the pacing guide recommending the time it should take to teach lessons (approximate number of weeks) and curriculum units that lists suggested lessons and student activities for teaching science and mathematics at grade four. During the data collection period science instruction expectation by teachers was to cover unit one which is nine weeks of science instruction broken into three weeks of intervention skills, five weeks of learning new science concepts and one week designated to review and assessment. Mathematics instruction expected during the time of data collection consisted of unit one which is nine weeks of instruction covering three weeks of intervention and six weeks of learning new mathematic concepts.

Analysis

The fourth-grade science scope and sequence has five units consisting of topics aligned with NGSS that should be taught throughout the course of the year. During the period of gathering information for the study two topics and three standards were covered in the fourth-grade science curriculum unit one. The fourth-grade mathematics scope and sequence are aligned with common core state standards and consists of 14 topics covering the four quarters of calendar instructional days. During the period gathering information three topics were covered.

Mathematics and Science Readiness Tool

A school science and mathematics readiness tool were provided to school leaders of Schools A and B. The self-reflection school readiness tool was used for school leaders to self-assess their science and mathematics programs and to help determine whether the school mathematics and science program was in an early stage, developing stage, prepared, or a model for science and mathematics learning. At school A one school leader (50% of respondents) completed the school readiness tool and at school B two school leaders (100% of respondents) completed the mathematics and science readiness tool. Each school leader participated in a telephone conference to self-assess their schools' program for mathematics and science readiness. During the structured interview clarifying questions were provided prior to the researcher reading the statement and recording the reported answers on the tool. Each responded were asked same clarifying questions before the school leader provided a rating of their program in each area of the science and mathematics tool based on the ratings of Early-1, Developing 2, Prepared 3, or Model 4. (Friday Institute, 2019)   The school leader's self-assessment overall rank in the five areas of the science and mathematics readiness tool is depicted below.

Figure 4

Science and Mathematics School Readiness Scores by School Leader

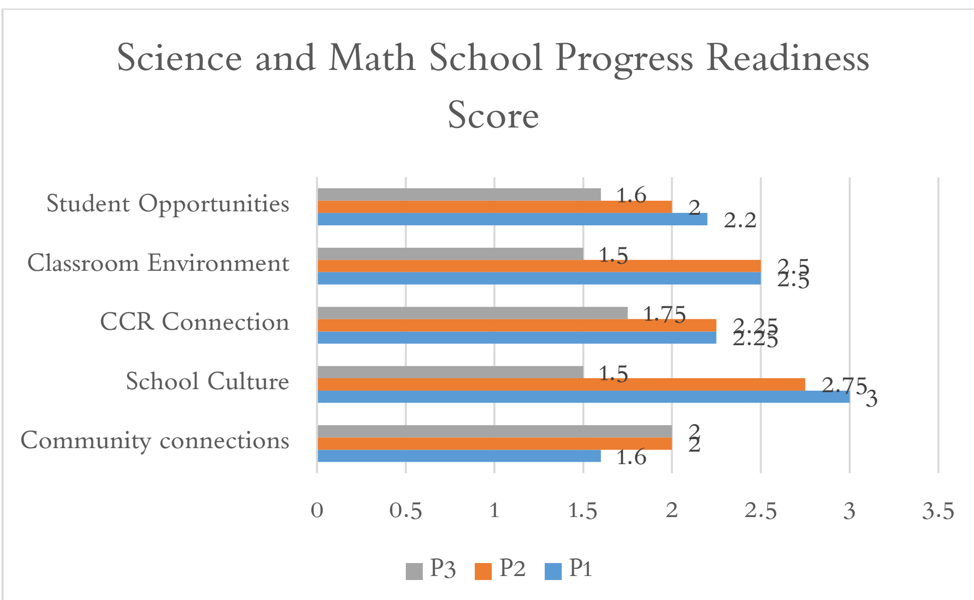


Figure 4 and Tables 7 & 8 shows the mean score from each category on the self-report tool of the three school leaders. P1 is the leader of school A and P2 and P3 are leaders in school B. School leaders self-assessed themselves in each category based on a scale of 1-4 of mathematics and science readiness with 1 as Early, 2 Developing, 3 Prepared, and 4 Model.

Tables 7 & 8 reflect the mean scores of how participating school leaders viewed their mathematics and science programs. Based on each category of the tool building leaders provided a score from the Likert scale. Those scores were averaged per building and the mean score was correlated to a stage of the program readiness based on one of four stages of development.

Table 7

Science and Mathematics Readiness Responses for School A

Descriptor	Mean Score	Stage
Student Opportunity	2.2	Developing
Classroom Environment	2.5	Developing
School Structures	2.25	Developing
School Culture	3	Prepared
Community Connections	1.6	Early
Overall /Readiness	2.31	Developing

Note: The scores depicted in Table 7 are based on an ordinal measure of categories based on subcategories on the Science and Mathematics Readiness Tool. See Appendix
The scores are self-reported from one respondent equating to 50% of building staff. The mean score is used to correlate the stage of development Adapted from the Friday Institute, 2014.

Table 8

Science and Mathematics Readiness Responses for School B

Descriptor	Score	Mean	Stage
Student Opportunity	2,1.6	1.8	Early
Classroom Environment	1.5,2.5	2	Developing
School Structures	1.75,2.25	2	Developing
School Culture	2,2.75	2.37	Developing
Community Connections	1,2	1.5	Early
Overall /Readiness		1.93	Early

Note: The scores depicted in Table 8 are based on an ordinal measure of categories based on subcategories on the Science and Mathematics Readiness Tool. See Appendix The scores are self-reported from two respondents equating to 100% of the building staff. The mean score is used to correlate with the stage of development. Adapted from the Friday Institute, 2014.

Analysis:

Descriptive statistics were created using SPSS to compute the minimum and maximum score responses form the science and mathematics readiness tools. Three respondents provided data which equated to 100% of participants. Table 7 shows the range of responses based on the ordinal measure of one to four. The stages of development are depicted in Tables 7 & 8. The mean scores shows the ranges of responses from the individuals who participated in the study. These ranges show the degree to which the school leaders self-reflected and evaluated their school science and mathematics scores in five areas.

These scores are important as they identified areas of strengths and weaknesses in the current school program and starts as initial point for conversation and action to improve the culture and climate for teaching mathematics and science. Often school leaders are asked to provide evidence of need when requesting funding and additional resources to enhance or improve school programs. This data can be used to justify the needs for a more equitable based science and mathematics program.

Question 2: Time allocation to science and mathematics

Question two explored the time allocated to learn mathematics and science in elementary schools. Data collected for this question consisted of master schedules, district policy and a teacher self-report tool for time on task for mathematics and science. District protocol was provided to all staff regarding the minutes of instruction, sample master schedules, type of instruction and other necessary supports for teaching and learning during the pandemic. Minutes of instruction expected and scheduled as per state and district guidelines are the same as mentioned earlier in this chapter under district protocol and guidelines for remote learning.

District protocol for teaching and learning in core areas during remote learning guidelines for grades 3-5 requires the following minimum instructional minutes in the core areas to be reflected in master schedules; ELA/reading a minimum of 80 minutes of instruction providing 35 minutes of synchronous learning, 35 minutes asynchronous learning, and 10 minutes of reading. Mathematics a minimum of 70 minutes of instruction providing 35 minutes of synchronous learning and 35 minutes of asynchronous learning and science a minimum of 25 minutes of synchronous learning.

Master schedules for school A reflects 85 minutes of daily mathematics instruction and 50 minutes of daily science instruction broken into two groups to support learning. The master schedule for school B reflects 140 minutes of daily mathematics instruction and 50 minutes of science instruction broken into two groups to support learning.

Teacher self-report science and mathematics time on task tools were used to collect data over a six-week period. Two of the four teachers participated in the data collection. The self-report tool from school A reflected a daily average of 12 minutes of science instruction per week during the six-week period and a daily average of 63.6 minutes of instruction per mathematics per week. Minutes per week in school A to exclude instruction during NWEA testing reflected 79.5 minutes per week of mathematics instruction and 12 minutes of instruction per week of science.

The self-report tool from school B reflected an average of 18.8 minutes of daily science instruction and an average of 83.2 minutes of daily mathematics instruction collected over a six-week period. The period of instruction vs. non instruction during the NWEA testing window is not reflected in the averages. According to district remote learning policy and protocol fourth grade teachers are to provide students with at least 80 minutes of daily ELA/reading instruction, 70 minutes of daily mathematics instruction, and 25 minutes of daily science instruction during remote learning.

Analysis:

SSPS was used to provide descriptive statistics of time on task for schools A and B. Table 9 reflects the minimum and maximum number of instructional minutes provided to students in mathematics and science at schools A and B. Teachers collected data for a six-week period beginning in August thru September. However, the NWEA assessment window varied at each school. Both schools' data reflected that only three of the six weeks of instruction were provided before the assessment was administered. District practices for assessing students is to administer an assessment for every two to six weeks of instruction. Three weeks of instruction was an effective practice although it was not projected in the study. The reduction for weeks of instruction and content can be perceived as a limiting factor in both schools and was reflected in the data.

Table 9

Time on Task Self Report of Instructional Minutes for Mathematics and Science Descriptive Statistics

Subject/School	N=Weeks of Instruction	Minimum (Time in min.)	Maximum (Time in min.)	Mean (Time in min.)	Standard Deviation
Science (A)	3	0	30	12.00	15.213
Mathematics(A)	3	0	120	78.00	46.476
Science (B)	3	17	20	18.73	1.163
Mathematics (B)	3	82	85	83.33	1.175

Note: Table 9 depicts the average number of weeks of instruction provided to students prior to taking the science and mathematics NWEA Fall 20 assessment. Three weeks of instruction equates to 15 days. The minimum and maximum number of minutes provided in each subject area based on a daily report is reflected. See Appendix G.

The Carrol Model of Learning Equation (1963) was modified and used for alignment to answer question two. The model provides numerical data to support the mean of instructional minutes provided to student opportunity to learn, perseverance, and time needed to calculate the learning ratios. Opportunities to learn are types of tasks afforded to students during the instructional time frame and examples of type of task are outlined in Appendix B & F under student opportunities. Perseverance is the time students were engaged based on the mean of the maximum time of instruction from data collection. Time needed is content specific, based on national, state or district protocols. Science time needed is based on posits from NSTA of 60 minutes of daily science instruction and mathematics time is based on district protocols to support time on task (NSTA, 2018). Using the Carroll Model Learning equation p. 24, Table 10 shows the learning ratios for schools A and B based on data from the teacher self-report time on task logs.

Table 10

Carroll Model of Learning Equation (modified) for Schools A & B

School A	Opportunity (mean)	Perseverance	Time Needed	Learning Ratio
Science	12 min	30 (Max)	60 m	20%
Mathematics	78 min	120 (max)	120 m	65%
School B	Opportunity (mean)	Perseverance	Time Needed	Learning Ratio
Science	18 min	20 (Max)	60 m	30%
Mathematics	83 min	85 (max)	120 m	69%

Note: Learning Ratio Time = Time Spent/Time Needed 12/60 Students spent less than a third of the time needed to support learning in science in both Schools A & B. In mathematics students spent more than half of the time learning but still did not meet 100% of time on task needed to learn as compared to opportunity afforded vs. time needed.

Based on the data the opportunity to learn science and mathematics provided to students was below district expectations and therefore equate to a deficiency in the learning ratio to maximize instruction. At the national level the mean science opportunity for learning range is reduced by two to eighteen minutes and the mean mathematics opportunity for learning range is reduced by thirty-nine to forty-two minutes. To ensure students receive the most effective allocation of time for science and mathematics to support a 100% learning ratio, time allotted to both content areas will need to increase to the maximum time needed.

Question 3: Student Perceptions of Science and Mathematics (No data collected)

Question three explored student attitudes and perceptions regarding their science and mathematics learning and instruction provided by their teacher(s). A student perception survey (Appendix D) was created to administer to students using an online platform. The survey questions focused on the phenomena of time to learn, opportunities to learn, and their account or event (phenomenon) of science and mathematics instruction received.

Recruitment method of students was via communication of teachers and the building principals who provided teachers autonomy in the venue for recruiting students. Teachers from both schools were requested to allow the investigator to join virtual classrooms to speak with students regarding their interest in the study. Ecompliance protocol was followed to receive verbal consent via google meet to talk with students. School A only five students verbally agreed to participate and school B only two students verbally agreed to participate. Consent forms were not received from either school confirming student participation and parent consent notifications were not required. Due to the low number of student participants in the classroom google meets with students during the investigator recruitment session and unsuccessful teacher attempts during class to increase student participation during the COVID-19 remote learning period; this piece of data is not reflected in the study as planned. However, student cohort achievement data from schools A and B of the participating teachers was available and used in the analysis to support time on task and student achievement without student perception input of their learning during this period.

Question 4: Teacher and Principal Perceptions of Science and Mathematics Learning

Question four explored teacher and principal perceptions of mathematics and science learning of fourth grade students in their schools. The two participating schools have a total of four building leaders and four mathematics and science teachers consisting of two leaders per school and two teachers per school. At School A one school leader completed the online mathematics and science surveys. At School B two school leaders completed the online science and mathematics surveys. The teacher and student perception surveys were designed to examine how each group perceives mathematics and science teaching and learning in their schools. The survey questions were designed to target how teachers view time to teach mathematics and science, how students view learning science and mathematics, student capabilities to learn mathematics and science, teaching philosophy/beliefs of mathematics and science, and student opportunities to learn mathematics and science.

Teacher Survey Responses and Analysis (Table 11)

Teacher survey response rates on the four surveys emailed to teachers returned with a 100% response rate on all items from both teachers. One teacher response from each school equated to 50% of mathematics and science teachers per school. Questions directly related to student opportunities to learn science are questions: 7, 13, 16, 19, 20, 22, 24, and 26. These questions are of particular importance because they relate to time and opportunities to learn science during remote learning conditions. See Table 10. Mathematics questions relating to student opportunities to learn depicted in the table below are questions 7, 10, 14, 17, 20, 24 and 26. See Table 11 for frequency and key items of responses. See Appendix E & F for survey questions.

Table 11:

Frequency of Teacher Participant Responses to Science Survey: Items on Student Opportunities (Scale Score 1=Strongly Disagree & Scale Score 5=Strongly Agree)

Item #	Question	1 Strongly Disagree	2	3	4	5 Strongly Agree
7	My students learn science for at least 30 minutes a day		2 (100%)			
13	I have enough time during the school day to teach science.	1 (50%)	1 (50%)			
16	Students have enough time to finish science assignments during class.		2(100%)			
19	I think it is important for students to express their views in science.					2(100%)
20	Students often engage in discussion in science.					2 (100%)
22	Within the last two weeks students developed models in science	1 (50%)		1 (50%)		
24	Question: In the past week my students participated in the following activities in science.		YES	NO		
24	Used technology Conduct an experiment Created a data table Take observations and recorded data Designed something Found a solution to a real-world problem	A. B. C. D. E. F.	2 1 1 2 2	 1 1 2		
	Question	Subject	1	2		
26	As an elementary education how, much time do you feel should be allocated to the following subject areas: Science, Mathematics, Reading?	SC MA RE	45 min. 90 min. 90 min.	45min. 90 90		

Note: See Appendix E for survey questions.

Table 12

Frequency of Teacher Participant Responses to Mathematics Survey: Items on Student Opportunities (Scale Score 1=Strongly Disagree & Scale Score 5=Strongly Agree

Item #	Question	1 Strongly Disagree	2	3	4	5 Strongly Agree
7	My students learn math for at least 30 minutes a day					2 (100%)
10	Within the last two weeks students used manipulatives in math (virtually or face to face).				1 (50%)	1 (50%)
14	I have enough time during the school day to teach math.			1 (50%)		1 (50%)
17	Students have enough time to finish science assignments during class.		1 (50%)			1 (50%)
20	I think it is important for students to express their views in science.		1 (50%)			1 (50%)
24	Students often engage in discussion in math.				1 (50%)	1 (50%)
26	Question: In the past 2 weeks my students participated in the following activities in math		YES	NO		
	Used technology Conduct an investigation Created a data table Analyze and record data Designed something Find a solution to a real-world problem	A. B. C. D. E. F.	2 1 1 2 1	 1 1 2 1		
		Question	1	2		
28	As an elementary education how, much time do you feel should be allocated to the following subject areas: Science, Mathematics, Reading	SC MA RE	45 90 90	45 90 90		

Note: See Appendix E for survey questions.

The principal mathematics and science surveys (Appendix C & D) consist of questions focusing on principal philosophy on mathematics and science and principal beliefs of the elementary mathematics and science programs at their schools to include questions regarding time and opportunities to teach mathematics and science. Table 13 provides a brief framework for the Science and Mathematics Readiness Tool (Appendix A).

Table 13

Science and Mathematics Readiness Framework

Section Title	**No. of Questions**	**Measures**	**Response Type**
Student Opportunities	9	Lesson plans, Observations, Self-Report	8 scaled (Likert) Strongly disagree to strongly agree 1 open ended
Classroom Environment	4	Lesson plans, Observations, Self-Report	Scaled Strongly disagree to strongly agree
School Structures	8	PD schedules, Master Schedules Self-Report	Scaled (Likert)
School Culture	9	School Demographic Data, School Improvement Plans, School Vision and Mission Statements, Self-Report	Scaled (Likert)
Community Connection	1	School Partnerships Self Report	Scaled (Likert)

Note: See Appendix A for questionnaire.

The principal surveys were emailed to all participants. A 100% response rate was received. All data collected via google survey forms were translated to ensure identity of responses remained anonymous. Tables 13 and 14 below show frequency of responses related to student opportunities to learn mathematics and science. Questions 1, 3, 5, 8, 14, 20 and 32 reflect data regarding opportunities to learn mathematics and science.

Table 14

Frequency of Principal Participant Responses to Science Survey: Items on Student Opportunities (1= Strongly Disagree, 5= Strongly Agree)

Item #	Question: Regarding science at my school, I….	1 Strongly Disagree	2	3	4	5 Strongly Agree
1	Make sure teachers have access to technology tools that facilitate their work (e.g., chrome books, desktops, smartboards, virtual applications, software, digital management systems, etc.) in science.				1 (33%)	2 (66.7%)
3	Support teachers to incorporate the teaching of career readiness skills (e.g., Communication, collaboration, problem solving) in science.			2 (66.7%)		1 (33.3%)
5	Support teachers to implement project-based learning in science.			1 (33.3%)	1 (33.3%)	1 (33.3%)
8	Provide space for students to collaborate work on projects, hold exhibitions, etc. in science			1 (33.3%)	1 (33.3%)	1 (33.3%)
14	Allow teachers and students enough time to teach and learn science			1 (33.3%)		2 (66.7%)
20	Implement practices to increase participation of				2 (66.7%))	1 (33.3%)

	student groups underrepresented in science.					
	Question	Subject	1	2	3	
32	As a school leader how, much time do you feel should be allocated to the following subject areas: Science, Mathematics, Reading?	SC MA RE	30-45 60 NR	45 90 120	30-45 100 120	

Note: See Appendix B for survey questions.

Table 15

Frequency of Principal Participant Responses to Mathematics Survey: Items on Student Opportunities (1= Strongly Disagree, 5= Strongly Agree)

Item #	Question	1 Strongly Disagree	2	3	4	5 Strongly Agree
1	Make sure teachers have access to technology tools that facilitate their work (e.g., chrome books, desktops, smartboards, virtual applications, software, digital management systems, etc.) in math.					2 (100%)
3	Support teachers to incorporate the teaching of career readiness skills (e.g., Communication, collaboration, problem solving) in math.				1 (50%)	1 (50%)
5	Support teachers to implement project-based learning in math.			1 (50%)		1 (50%)
8	Provide space for students to collaborate work on projects, hold exhibitions, etc. in math.		1 (50%)			1 (50%)

14	Allow teachers and students enough time to teach and learn math.		1 (50%)			1 (50%)
20	Implement practices to increase participation of student groups underrepresented in math.				1 (50%)	1 (50%)
		Question	1	2	3	
32	As a school leader how, much time do you feel should be allocated to the following subject areas: Science, Mathematics, Reading?	SC MA RE	45 90 90	45 90 90		

Note: See Appendix C for survey questions.

Question 5: What is the relationship between instructional time and science and mathematics achievement of fourth grade students in elementary school settings?

Question five explored the relationship between time allocated to mathematics and science instruction and student achievement in these areas as measured by the Fall NWEA assessment (District Assessment Calendar, 2020). The NWEA assessment is a midwestern state and local school district benchmark that is administered to students three times per year once in the fall, winter, and spring. The Fall NWEA assessment content is aligned to the state and national standards addressing critical domains of Common Core mathematics and the Next Generation Science Standards (Achieve, Inc. 2013a & b). The Fall SY 20 NWEA assessment data provided was restricted in reliability of test scores due to online testing and remote learning testing conditions. The testing window for the Fall NWEA covers three to four weeks of instruction during the six-week data collection period. The data collected and analyzed for the NWEA Fall 20 assessment is based on a mean of three weeks of instruction between the two participating schools. The Fall 2020 NWEA mathematics and science assessments are skill-based assessments which assessed student knowledge based on prior year (Fall 2019) skills and content knowledge.

Conditions unique to the testing administration during the data collection period was the remote learning district protocol which called for three weeks of intervention/essential skills to support any gaps or loss of learning from the prior year due to Covid 19 schedule adjustments in time or content. Data collection and analysis compares science and mathematics achievement scores of participating students. See Table 16 group statistics. T test and paired sample tests were used to support analysis of time for learning and student achievement. Under usual conditions the state requires school districts to achieve a 95% participation rate. The state participation rate was waived by the state assessment department and the participation rates of 85% for mathematics and 87% for science is distinctively lower than normal due to remote learning conditions. Data collected was cohort data depicting mathematics and science scores of all fourth-grade students attending schools A and B who were tested remotely during the data collection period.

Table 16 reflects the relationship between the number of instructional minutes (time on task) and science and mathematics performance of students who completed the Fall 2020 NWEA assessment. The total sample size was 112. Based on this data there appear to be a positive relationship between the number of minutes and student performance. However, both means of student performance are below the target proficiency levels for science and mathematics. These mean scores are based on a proficiency scale for the NWEA assessment. Targets of expected norms for levels of achievement are found in Table 3 on page 22.

Table 16

Instructional Minutes and Science and Mathematics Student Achievement NWEA mean scores of 4th Grade Students Group Statistics

Group Statistics						
NWEA Achievement Level	School	Time on Task (min.)	N	Mean NWEA Score	Std. Deviation	Std. Error Mean
Science	A	12	59	179.00	14.220	1.851
	B	18	53	182.68	8.648	1.188
Mathematics	A	78	59	182.32	14.709	1.915
	B	83	53	188.08	15.077	2.071

Note: Table depicts the relationship between time on task and mathematics of fourth grade students of teachers who participated in the study. Min. means minutes. See Appendix H & I.

Table 17 reflects paired differences between mathematics and science achievement of fourth grade students at Schools A and B. The data reflects the differences between the mean scores of mathematics and science at each school. There is a 95% confidence level that the mean score for pair 2 will be higher than the mean score of pair 1 based on the variables of time. The relationship between the two is non directional which means the relationship can be positive or negative. The mean scores can have a range of plus or minus the standard deviation based on the minutes of instruction and sample size. For Pair 1 the obtained value for t is greater than the critical value which means the null hypothesis is rejected and that there is a relationship between time and student achievement. For Pair 2 the obtained value for t is significantly less than the critical value which means a type 1 or type 2 error has possibly occurred and a new test hypothesis could possibly be explored for that specific data set. However, the mean score for mathematics is higher than the mean score of science which rejects the null hypothesis for that data set.

Table 17

Paired Samples Test for Mathematics and Science between Schools A and B

Paired Samples Test

Paired Differences					95% Confidence Interval of the Difference				
Math/Science A&B		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2 tailed)
Pair 1	Math Science	3.695	13.063	1.701	.291	7.099	2.173	58	.034
Pair 2	Math Science	1.792	14.047	1.930	-2.079	5.664	.929	52	.357

Table 18 p.88 shows the total differences between NWEA mathematics and science scores for schools A & B. The total number of students who tested both science and mathematics is 112. The total mean for mathematics scores (185.24) based on the time spent on instruction is higher than the total mean for science scores (182.45) based on the number of instructional minutes. This analysis reflect that if the instruction and allocation of time in both core subjects remain the same there is a 95% confidence interval that the mean score of mathematics will be higher than the mean score of science, thus rejecting the null hypothesis that there is no relationship between time on task and fourth grade science and mathematics achievement. The difference between the means of the two groups of scores is 1.8, where the science mean was subtracted from the mathematics mean as more instructional time is allocated to mathematics. The standard error means are measures of the sample.

Table 18

T-Test Total Paired Samples Statistics for Grade 4 Mathematics and Science Achievement scores

Schools A & B	Mean Score	N	Std. Deviation	Std. Error Mean
Total Mathematics	185.24	112	15.014	1.419
Total Science	182.45	112	12.411	1.173

Note: Paired sample test for total mean of mathematics and science scores for schools A & B. Std. stands for standard deviation and standard error mean. N is the total sample size (112) of mathematics and science scores. See Appendix H&I. Source: District NWEA FY 2020.

Based on district metrics the sample population of 112 students who tested in both schools decreased due to integrity of the test scores under remote testing conditions. Many factors were accounted for during the testing window. An example was number of minutes that was allotted for the test sessions, environmental factors, and trends and patterns of individual and group performance data. Table 19 shows the sample size n=94 for mathematics and n=84 for science. The testing sample of n=112 is reflective of a random set of students who tested on both mathematics and science assessments in classes of participating teachers. See appendix H & I.

Table 19

Results for Fourth Grade Students on Fall SY 20 NWEA Assessment

Results for Minutes of Instruction and Math and Science Achievement of Fourth Grade Students

School	Avg. # of minutes of instruction per school per teacher participant		Fall NWEA Mathematics		Fall NWEA Science		Fall NWEA Reading	
			School A **N=48**/80~60%		School A **N=43**/80~53%		School A **N=38**/80~47%	
			School B **N=46**/75~61%		School B **N=41/**75~54%		School B **N=38**/75~50%	
			National Status Norms					
A	Math 79.5 Min.	Science 12 Min.	Not Met **Math** 37 77.08%	Met **Math** 11 22.92%	Not Met **Science** 32 74.42%	Met **Science** 11 25.58%	Not Met **Reading** 28 73.68%	Met **Reading** 10 26.32%
B	Math 83.2 Min.	Science 18.8 Min.	Not Met **Math** 39 84.78%	Met **Math** 7 15.22%	Not Met **Science** 35 85.37%	Met **Science** 6 13.95%	Not Met **Reading** 30 78.95%	Met **Reading** 8 21.05%

Note: Reliable tests results from the sample population of 112 reduced the secondary performance data to n=94 for mathematics and n=84 for science. Data retrieved from the district assessment office.

Analysis of test results shown in Table 19 reflects that the higher minutes of mathematics instruction yielded a higher number of students who met proficiency as compared to the number of science students who met proficiency. This result is true based on the data for School A and School B. In comparison to other tables reflected in study the smaller sample sizes as compared to the initial sample of 112 revealed the same results regarding science and mathematics achievement once again rejecting the null hypothesis.

Reflection

Gathering and analyzing the data during the pandemic was the most interesting process for me throughout the study. The instructional day was shortened, the curriculum resources were modified, time allocation for core subjects was modified, assessment practices were adjusted, and the teaching anxiety was increased for everyone. I found that gathering the data through a familiar platform was a delimiting factor. Although the google platform is not something used during standard research projects this mode of surveying staff and students was more effective than the use of other platforms such as Qualtrics and survey monkey. All raw data gathered were automatically generated in summary reports and charts that made the ease of converting information for analysis into SPSS.

I wondered how I could support the teachers in my role as a district science leader to provide this data with no biases and report it with integrity during a time of uncertainty for the most effective strategies for a constructivist view of learning for both science and mathematics when hand-on student learning is a challenge. The perspectives I hold from the view of a school leader are dynamic. My relationship with teachers changed instantly shifting from one role to the other. Preparation for instruction during this time was an opportunity for a self-assessment for all staff specifically in the use and pedagogy of delivering virtual instruction and the use of technology. These factors were a determinant to the limitation of instructional effectiveness afforded to students. Regardless of the preparation there were variances in the use and implementation of technology to provide instruction and the type of time on task activities provided throughout the data collection period. To support staff during the recording of time on task of science and mathematics teachers were allowed to self-report. This reporting method and collection of receiving the data was more user friendly since both teachers in the study teach both mathematics and science. From a research perspective this task would have been exceptionally difficult if the teachers of science and mathematics were different allowing for a greater need for recruitment of teachers, which in turn would add additional variables. What I initially thought would be a limitation of lowering the number of participants became a delimiting constant variable. This factor allowed for a more cohesive performance data set when gathering secondary data for student performance on the grade four NWEA science and mathematics assessments.

A decision to use SPSS vs. SAS for the analytics was based on prior use and knowledge of SPSS as well as access. The variables selected time allocation, staff perceptions, program readiness, and student achievement, were the most relevant factors to best answer the research questions. Descriptive statistics were used to explain phenomenon of time and differences and commonalities of staff perceptions of science and mathematics in their classrooms or school programs.

Results from the school leader's science and mathematics readiness tool were surprising. Building leaders were very candid and reflective in their responses in the structured interviews. They provided examples to justify their scores for the science and mathematics categories depicted in Tables 7 and 8. These examples or non-examples defined for purposes of this paper were evidence for appropriate programming which is extremely powerful as it sets the stage for next steps for identifying and guiding the developing strengths and mitigating the challenges for improvement of mathematics and science learning.

CHAPTER 5
CONCLUSIONS

Introduction

Science and mathematics have long been a topic of discussion for providing equity and opportunity for those who have been underrepresented in the areas of mathematics. science, engineering and/or technology. The national assessment of educational progress has shared data that while gaps are closing between minority and non-minority students those who receive free and reduced lunch are still scoring lower in mathematics and science. School staff that participated in this study provide opportunities to teach and for students to learn science and mathematics who are schooled and reside in an area of low socioeconomics which normally is a group predicted for underrepresentation in future years in careers and advanced studies in science and mathematics. A null hypothesis was developed and used as a starting point to measure results of the study. This initial step will allow for review and manipulation of time allocation to support the standard instructional day as well as a modified day due to conditions of crisis such as the Covid 19 pandemic.

Major Findings

Based on school master schedules, curriculum resources and district and state protocols both schools A and B participating in study created opportunities as evidenced from school schedules for fourth grade students to learn mathematics and science. However, time allocation was not equitable to support the curriculum expectations for both subjects. Self-reports of minutes of instruction reflected the minimum number of instructional minutes based on weeks of instruction to support testing science and mathematics for fourth grade students during the data collection period.

District protocol requests a minimum of 2-6 weeks of instruction prior to testing. Science instruction prior to testing for both schools A and B were three weeks prior to the NWEA assessment and mathematics instruction was 4.5 to 5 weeks of instruction for schools A and B. There was at least a one-point five-week difference in the time allocated for mathematics instruction prior to testing which again proved favorable for the mean achievement scores of mathematics, and a slightly lower score for science achievement.

Based on the Carroll Model of Learning (Table 8) the mean learning ratio for the participating schools in science is 25% and the mean ratio for mathematics is 67%. The total population of fourth grade students for schools A and B is 155. The total population of fourth grade students enrolled in the district during the study was 346. The targeted sample size was 45% of the district fourth grade students. Secondary data revealed of the 155 students 112 students were assessed based on the mean minutes of instruction in science and mathematics.

Survey instrument respondents equated to 50% of the mathematics and science departments of teaching staff at schools A and B and 30% of the building leadership of the district's elementary staff supporting fourth grade students. Based on Frequency Tables respondents' self-reflection regarding time allocation revealed the amount of time allocation for the core subjects of science, mathematics and reading are as follows: science should be 45 minutes of instruction, mathematics should be 90 minutes of instruction, and reading should be 120 minutes of instruction. Based on the Carroll Model of Learning (Table 10) time allocations required as per district staff still reveals some limitations of opportunities to learn mathematics and science. Surprises from the data analysis were that more time allocation is needed for science and less time allocation is needed for mathematics. However, all staff respondents indicated the maximum of 120 minutes is needed for reading. Reading secondary data was not hypothesized or reflected in study. The science and mathematics readiness self-report tools surprisingly revealed that building leadership reported that their programs for preparing students in science and mathematics are in a stage of development. Based on descriptive statistics student opportunities and college and career readiness were the lowest mean averages from the survey responses placing school programs in the early stage to support preparation of fourth grade students.

Teacher and staff perception data were used in addition to student performance of fourth grade students to examine whether a relationship exists between student performance and time on task. Time on task or opportunities to learn mathematics and science are described as the following activities such as, but not limited to the student use of technology (Chromebook or computer), conducting an experiment or investigation, creating a data table, taking observations, and recording data, designing something, or finding solutions to a real-world problem. Results from the paired sample T-test with a 95% confidence level and a .05 sig value indicated the null hypothesis there is no relationship between time on task and fourth grade student achievement in mathematics and science was rejected. Other findings that revealed there is a relationship between time on task and mathematics and science achievement varied based on school conditions and opportunities to learn. Table 16 reflects that the mathematic scores were higher than science scores. However, learning ratios show there are disparities between time allocated and student achievement. The lower the ratio the lower the mean score and the higher the ratio the higher the mean score as it pertained to science and mathematics achievement.

Student achievement data from the study noted that mean mathematics and science scores are well below the proficiency benchmarks for a midwestern state benchmark NWEA. The mean scores for 4th grade students in science is 182 and the mean score for mathematics is 185. The expectancy levels of proficiency based on FALL SY 20 NWEA assessment for both science and mathematics were below the norms of expected achievement as per Table 2, p. 22.

Implications

Implications of the study is to strengthen elementary mathematics and science programs and to provide equity of student opportunity for students in these areas by increasing the number of minutes allocated to science instruction as per the research and position statements of NSTA of providing science instruction to students in the early years to strengthen skill levels for later learning opportunities. Mathematic implications are to possibly evaluate the number of instructional minutes allocated to mathematics and how the time is being used during the mathematics instructional blocks to better gain insight on why the fourth-grade student performance is not significantly higher than science performance based on the minutes of instruction allocated to learn mathematics. The science and mathematics programs can be strengthened using data from the science and mathematics readiness tool to better support school improvement goals, staffing requirements, and criteria to support student opportunities to increase and sustain mathematics and science performance in elementary school settings particularly at the fourth-grade level. The perception surveys can be utilized by staff and students in various ways such as, by elementary school leaders to gain insight on preparation of teachers to teach science and mathematics, for teachers to reflect on their practices and beliefs of science and mathematics instruction and for students to reflect on their abilities to achieve in science and mathematics based on instruction they receive in these areas.

Current proficiency rates from mean scores for science are well below the expected proficiency rates based on midwestern proficiency benchmarks for 2032. The 2020 proficiency rates for 5th grade mathematics are for all students 46. 23%, for Low income 35.62% and for black students 31.94%. The proficiency rates for science for all students are 60.25%, 47.67% for low income, and 39.75 for black students. Based on mean scores for the district 4th grade students who will take the 5th grade mathematics and science state assessments as a cohort the SY 21 school year the mean proficiency rates for students who met in school A for fourth grade students in mathematics and science based on the NWEA results (Table 19) were 22.9% and 25.58%. For school B the proficiency rates for SY 20 for fourth grade students were 15.22% mathematics and 13.95% for science. These proficiency rates are well below the projected proficiency rates for 5th grade students for the SY 21. These mean proficiency rates can be used as predictors for cohort proficiencies for these students who will test on district and state assessments for the SY 2021/2022 school year.

Future Concerns

Based on NSTA posits of 60 minutes of instruction for science K-12 future concerns for the district is the ability to increase minutes of instruction in science with a minimum of 45 minutes and a maximum of 60 minutes. It is possible to pilot the various time frames if borrowing this time from other contents is a challenge or concern. Varying the times might have an ability to show a cause-and-effect relationship between time on task/minutes of instruction and science achievement. Another concern is the impact science can have on reading. The study did not focus on student achievement in reading but if integration of non-fiction is a concern an increase in science instructional time focusing on science literacy is a possible solution.

Closing the gap between minority students and non-minority students in science and mathematics is a continued concern. However, providing an equitable opportunity for student learning in all core subjects is a constant challenge for many public schools and it is more challenging when there are high poverty indicators involved. Data from students who receive free and reduced lunch on three different assessments reflected gaps of at least 20 or more points. See figure 4 p.40.

The midwestern school district in this study is in a zip code that is associated with a low socioeconomic base. This factor alone has been evidenced throughout this study to influence student performance on district, state, national and international levels of achievement in mathematics and science. Future concerns of accountability in mathematics and science as well as the lack of minorities represented in science and engineering fields will take a courageous conversation in policy changes and practices to explain why all resources fiscal and non-fiscal are not allocated equitably among core content areas, specifically those involved with high stakes testing.

One of the major concerns in this study I found during the research that while science is a concern nationally, the national science assessment did not provide a mapping measurement to correlate national and state data for science as it did for mathematics and reading (NAEP, 2019). School districts specifically those which service poor, disadvantaged, and underrepresented groups in the science and mathematics fields, must take ownership of every aspect to ensure an equity-based education and opportunity is afforded to minimize gaps. It is my concern that if at the national level targets of proficiency are not provided to support instruction in core subjects such as science and mathematics than it might not have the trickle-down effect at the state and local levels to impact implementation for a need to change how non fiscal resources such as instructional time is allocated.

Lastly, once the time is allocated how the time is used is an equal concern. Conducting the study during the pandemic gave me a greater insight on how the use of time can impact student learning, not only for this situation but during another unforeseen crisis as well. This was evident in the types of learning provided asynchronous versus synchronous instruction and the decisions district leaders and teachers had to make to provide a scheduling of time to facilitate lessons and activities through nontraditional methods. A question I often wonder about for the future is how to better prepare teachers and students to maximize learning when resources do not always align with the practices and conditions most suited for learning a topic or content. For example, to what extent can virtual learning support the constructivist approach to science and mathematics and how can modification to resources best enhance learning in these areas? When I reflect on missed opportunities for certain groups, I see the bigger picture of long-term effects of under exposure leading to untapped potential for growth and economic opportunities for innovation due to oversight and under preparation of students in early schooling which can create missed opportunities not only for today's students but for tomorrows future of economic growth and diversity in the areas of science and mathematics.

Reflection Summary

The null hypothesis revealed that there is a correlation between time on task and student performance of fourth grade students in mathematics and science. However, I was surprised that the association between the two assessment scores (mathematics and science) of students were two tailed signifying that the relationship was non directional. Due to the latter other factors such as teacher preparation, the conditions of learning, and what time on task looks like to best support increased student achievement in elementary science and mathematics classes are areas to consider. Time on task must be intentional focusing on task specific learning opportunities inducing critical and analytical thinking such as student investigations, interpreting data, and observing and recording data to draw conclusions and explanations to make sense of phenomenon. I would state that time on task specific to certain learning opportunities and exposure must be in tandem with each other.

Conditions for learning science was probably the most unforeseeable challenge I anticipated. I knew and understood the nature of the pandemic and how it impacted society. However, through my own personal experiences during the pandemic I can never explain how decisions to expect the normalcy of what students should learn and how students can learn could become so challenging. In my role as a building leader, reflecting on teacher support I understood that certain factors impacting student learning was unfortunately expected. I anticipated that laboratory and discovery experiences might be limited, but I didn’t foresee challenges to these experiences conducted in the home environment. The key was always to have a solution. In my role as a science team lead that expectancy shifted to the need to become overly optimistic to intentionally push and prod teachers to use every trick of the trade to keep students engaged in science and knowing that science is very important as the nature of science is woven throughout the pandemic. What I gained from the experiences of the timeframe in which the research was conducted starting in March 2019, being an insider looking out as a school leader and transitioning thru the pandemic in 2020 from the lens of a district science leader my perspective changed to an outsider looking in, to support in alleviating deficits of learning loss. The pandemic gave a new insight to the art of teaching science. Horace Mann (1989) stated in the 1840's that "those who are apt to teach are acquainted with both common methods and unusual methods and know as many modes as cases that may arise" (p.20). I believe that if this statement was equated in todays' era of innovation it might state "teachers of science and mathematics must have the knowledge and pedagogy skills to teach all students (the cases that arise) in as many ways (modes) in addition to considering all situations and conditions of teaching from the instructors view and learning from the students view".

There were many limiting factors to consider during this study, but all were met with great strides and perseverance. When the school doors closed, the world opened the airways to Wi-Fi and internet to continue schooling and every aspect of student learning had to shift from the traditional lens to 21st century innovative thinking of instruction overnight. Mann stated in the 1800's that "lessons should be adjusted to the capacity of the scholar" (p. 22). This statement expands what students are capable of and not the lack of knowledge students exhibited. Expectations for learning were modified. However, narrowing the focus for key standards and curriculum topics was a challenge when preparing students for high stakes testing. The Next Generation Science Standards are an inviting expectation of not only learning science but applying scientific concepts. It is my belief that the science and mathematics data is not duly reflecting students' capabilities but a reflection of the exposure to science and the use of time allocation in both science and mathematics.

Descriptive statistics presented in chapter four revealed that the mean scores in fourth grade science (182) and mathematics (185) in one midwestern school district were below the expectations of norm set by the district. The mean scores were seven to nine points below the expectations of 194 and 199 for the fourth-grade level and below 10 points for predictions for the 5th grade score expectancies of 200 and 209 respectively. There has been a pattern of consistency for these scores over the past few years. Current data presented from the 2021 assessments revealed that there was very little change between the 2020 and 2021 assessment scores although the conditions for assessment and learning were unique for the school year 2019 and 2020. The new data with my current findings were surprising as test reliability was a huge factor of the data set collected. Normed participation rates by the state of 95% participation were waived. Participation rates for both mathematics and science during the data collection window of August thru September 2021 were below 95%. Student assessment participation in mathematics was 81.47% and 87.36% percent in science. As the science district leader, the goal for participation was 100% using the 5% not required by the state as a buffer to ensure the 95% participation rate was required. Another factor impacting the data collection was the reliability of test scores. All assessments were completed by students virtually in their homes and monitoring of test security was a challenge. Table 19 shows the actual sample and distribution of performance of results. Timed tests were almost null and void during the Covid 19 pandemic. Assessment of learning was required especially for science as the elementary state accountability assessment was recently modified for the 5th grade level which is a 3-5 grade span test of knowledge and science practices for that subject. Reflecting on the challenges of requiring every student to test remotely online during the pandemic presents an area focus for school districts to improve and enhance the support to teachers and students in non-traditional learning spaces to ensure effectiveness of instruction, student learning, and assessment protocols.

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Appendix A

School Science and Mathematics Readiness/Progress Tool

School Name: (Drop Down)

Date Completed:

Scoring Guide:

Early =1 Developing = 2 Prepared = 3 Model = 4

(1) Student Opportunities	Score	STEM Indicator
1.1 Students Investigating		
1.2 Students Working in Teams		
1.3 Learning Connected to CCR		
1.4 Students Using Technology		
1.5 Opportunities for Field Experiences/Outreach		
Overall "Student Opportunities "Score		
(2) Classroom Environment	Score	STEM Indicator
2.1 Instruction Integrating Math and Science		
2.2 Varied Learning Approaches		
2.3 Multiple Assessment Types		
2.4 Teacher Collaboration		
Overall "Classroom Environment" Score		
(3) School Structures	Score	STEM Indicator
3.1 Professional Learning Focus on Science and Math		
3.2 Physical Space for Projects		
3.3 Program Scheduling		
3.4 Strategic Staffing for science and math		
Overall "School Structures" Score		
(4) School Culture	Score	STEM Indicator
4.1 Vibrant Print Rich Math and Science Culture		

4.2 Serving Underrepresented Students		
4.3 Science and Math Schoolwide Plan		
4.4 Data-Informed Continuous Improvement		
Overall “School Culture” Score		
(5) Community Connections	Score	STEM Indicator
5.1 Science Museum Partnerships		
5.2 Science and/or Math Business Partnerships		
5.3 Science and/or Math College and/or University Partnerships		
Overall “Community Connections” Score		

School’s overall rank on the Science and Math Readiness/Progress Tool

Science and Math School Readiness/Progress	Score	STEM Indicator
(1) Student Opportunities		
(2) Classroom Environment		
(3) Learning Connected to CCR		
(4) School Culture		
(5) Community Connections		
Overall Science and Math School Progress/Readiness Score		

EARLY (0-30) DEVELOPING (31-50) PREPARED (51-70) MODEL (71-80)

Adapted from the North Carolina STEM Progress Rubric for Elementary Schools (2018)

Appendix B

Principal Science Survey

School: (Drop Down A or B)

Role: (Drop Down 1 or 2)

Directions: Please indicate your level of agreement or disagreement with each statement along the following scale.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Regarding science at my school, I…

1	Make sure teachers have access to instructional technology tools that facilitate their work (e.g., chrome books, desktops, smartboards, virtual applications, software, digital management systems, etc.) in science.	1	2	3	4	5
2	Ensure technical support is available for instructional technology tools in science.	1	2	3	4	5
3	Support teacher to incorporate the teaching of career readiness skills (e.g., communication, collaboration, problem solving) in science.	1	2	3	4	5
4	Enable collaboration of teachers across content areas in science.	1	2	3	4	5
5	Support teachers to implement project-based learning in science.	1	2	3	4	5
6	Share research and best practices with teachers in science	1	2	3	4	5
7	Set ambitious yet realistic (i.e., not too high, and not too low) goals in science.	1	2	3	4	5

8	Provide space for students to collaborate work on projects, hold exhibitions etc. in science.	1	2	3	4	5
9	Include teachers in decision making regarding the school program.	1	2	3	4	5
10	Encourage science culture of learning teachers and students.	1	2	3	4	5
11	Celebrate students work in science.	1	2	3	4	5
12	Regularly celebrate teachers work in the area of science.	1	2	3	4	5
13	Understand that inquiry-based teaching in science may take more time for some teachers.	1	2	3	4	5
14	Allow teachers and students enough time to teach and learn science,	1	2	3	4	5
15	Communicate clearly how teacher performance will be assessed in science.	1	2	3	4	5
16	Set clear expectations for teachers of science instruction.	1	2	3	4	5
17	Provide constructive feedback to teachers in science.	1	2	3	4	5
18	Model inquiry-based learning.	1	2	3	4	5
19	Have articulated a vision in science.	1	2	3	4	5
20	Implement practices to increase participation of student groups underrepresented in science.	1	2	3	4	5
21	Support the formal in-school provision of authentic learning experiences (e.g., industry tours, job shadowing workshops, speakers, (science) field trips.	1	2	3	4	5
22	Communicate how the science program supports or is itself part of the strategic plan for the school.	1	2	3	4	5
23	Include teachers in decisions about measuring student success in science.	1	2	3	4	5

24	Communicate to the larger community (parents, local businesses, etc.) about the schools' science program.	1	2	3	4	5
25	Request feedback from teachers on the progress of the science program.	1	2	3	4	5
26	Feel knowledgeable about the characteristics of teaching science.	1	2	3	4	5
27	Use an action plan to implement the schools' science program.	1	2	3	4	5
28	Provide consistent professional development specific to science.	1	2	3	4	5
29	Take measures to ensure the science program is engaging for students.	1	2	3	4	5
30	Feel confident in leading a science professional development.	1	2	3	4	5
31	Feel prepared to lead a science focused school program.	1	2	3	4	5

32. As a school leader how much time do you feel should be allocated to the following subject areas: (please answer in minutes of instruction)

Science: ________ Mathematics ________ Reading ________

Adapted from the North Carolina Friday Institute STEM Principal Leadership Survey (2014)

Appendix C

Principal Mathematics Survey

School: (Drop Down A or B)

Role: (Drop Down 1 or 2)

Directions: Please indicate your level of agreement or disagreement with each statement along the following scale.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Regarding science at my school, I…

1	Make sure teachers have access to instructional technology tools that facilitate their work (e.g., chrome books, desktops, smartboards, virtual applications, software, digital management systems, etc.) in math.	1	2	3	4	5
2	Ensure technical support is available for instructional technology tools in math.	1	2	3	4	5
3	Support teachers to incorporate the teaching of career readiness skills (e.g., communication, collaboration, problem solving) in math	1	2	3	4	5
4	Enable collaboration of teachers across content areas in math.	1	2	3	4	5
5	Support teachers to implement project-based learning in math.	1	2	3	4	5
6	Share research and best practices with teachers in math.	1	2	3	4	5
7	Set ambitious yet realistic (i.e., not too high, and not too low) goals in math.	1	2	3	4	5

8	Provide space for students to collaborate work on projects, hold exhibitions etc. in math.	1	2	3	4	5
9	Include teachers in decision making regarding the school program.	1	2	3	4	5
10	Encourage math culture of learning teachers and students.	1	2	3	4	5
11	Celebrate students work in math.	1	2	3	4	5
12	Regularly celebrate teachers work in the area of math.	1	2	3	4	5
13	Understand that inquiry-based teaching in math may take more time for some teachers.	1	2	3	4	5
14	Allow teachers and students enough time to teach and learn math.	1	2	3	4	5
15	Communicate clearly how teacher performance will be assessed in math.	1	2	3	4	5
16	Set clear expectations for teachers of math instruction.	1	2	3	4	5
17	Provide constructive feedback to teachers in math.	1	2	3	4	5
18	Model inquiry-based learning.	1	2	3	4	5
29	Have articulated a vision in math.	1	2	3	4	5
20	Implement practices to increase participation of student groups underrepresented in math	1	2	3	4	5
21	Support the formal in-school provision of authentic learning experiences (e.g., industry tours, job shadowing workshops, speakers, (math) field trips.	1	2	3	4	5
22	Communicate how the math program supports or is itself part of the strategic plan for the school.	1	2	3	4	5
23	Include teachers in decisions about measuring student success in math.	1	2	3	4	5

24	Communicate to the larger community (parents, local businesses, etc.) about the schools' math program.	1	2	3	4	5
25	Request feedback from teachers on the progress of the math program.	1	2	3	4	5
26	Feel knowledgeable about the characteristics of teaching math.	1	2	3	4	5
27	Use an action plan to implement the schools' math program.	1	2	3	4	5
28	Provide consistent professional development specific to math.	1	2	3	4	5
29	Take measures to ensure the math program is engaging for students	1	2	3	4	5
30	Feel confident in leading a math professional development	1	2	3	4	5
31	Feel prepared to lead a math focused school program	1	2	3	4	5

32. As a school leader how much time do you feel should be allocated to the following subject areas: (please answer in minutes of instruction)

Science: ________ Mathematics ________ Reading ________

Adapted from the North Carolina Friday Institute STEM Principal Leadership Survey (2014)

Appendix D

Student Science and Mathematics Survey

Directions: In this survey you will answer questions about you and what you think about math and science at your school. There are no wrong answers. You should choose the answer you think is best.

About you….

School: Drop down (A or B)

Student Number: (Number will be provided to student)

Gender: Drop down (male or female)

Grade 4

Subject: Drop down (math or science)

Age:

What do you think?

Select the best choice regarding each statement.

At my school…….

1	I like to read about science.	always	sometimes	never
2	I enjoy watching TV shows about science			
3.	My school has after school activities in science.			
4.	I am good at science			
5	Science is easy for me to learn			
6	I get good grades in science.			
7	I do science every day in my class.			
8	I know what my teacher expects me to do in science			
9.	I like learning science.			
10	Science is important			
11	I can use science in everyday life			
12	We do experiments in science			
13	We talk about science in our class.			
14	We use or make models in science.			
15	I have enough time to finish science activities in class.			

16	I understand what to do in science.			
17	We spend a lot of time in my class learning science			
18	Learning science will help me in the future			
19	I like to read about math			
20	I enjoy watching TV shows about math			
21	My school has after school activities in math			
22	I am good at math			
23	Math is easy for me to learn			
24	I do math every day in my class.			
25	I know what my teacher expects me to do in math.			
26	I like learning math.			
27	Math is important.			
28	I can use math in everyday life.			
29	We do investigations in math.			
30	We talk about math in our class			
31	I have enough time to finish math assignments in class.			
32	I understand what to do in math			
33	We spend a lot of time in my class learning math.			
34	Learning math will help me in the future.			

35. My teacher….

Makes learning science fun	Yes No
Helps me understand science	Yes No
Makes learning science easy	Yes No
Makes learning math fun	Yes No
Helps me understand math	Yes No

36. Tell whether you participated in each activity in the past week in science or math

Use Technology (chrome book or computer)	Yes	No
Conduct an experiment	Yes	No
Create a data table	Yes	No
Take observations and record data	Yes	No
Design something	Yes	No
Find a solution to a real-world problem	Yes	No

37. As an adult I plan to work in a job that uses math or science. Yes or No

38. I know someone who has a job that uses math or science. Yes or No

Thank you for taking this survey!!!

Adapted from the North Carolina Friday Institute Elementary Student STEM Survey (2012)

Appendix E

Teacher Science Perception Survey

Teachers my feel they have varying degrees of readiness and expectations of math and science in elementary schools.

Directions: In this survey you will answer questions about you and what you think about math and science learning at your school.

About you.

School (Drop Down A or B)

Teacher (1-8)

Subject (Drop Down Math or Science)

Type of Instruction: Drop Down, Self-Contained, or Departmentalized)

Gender: (Drop Down: Male or Female)

Years Teaching Math or Science: (Drop Down: 0-3, 3-5, 5-10, 0-15, 15 +

I have a degree focused on: (Drop Down: math, science, math, and science, reading or other)

Please indicate your level of agreement or disagreement with each statement along the following scale.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Regarding Science and Mathematics learning in my classroom…

1	I enjoy teaching science	1	2	3	4	5
2	Teaching science is easy for me	1	2	3	4	5
3	I understand science concepts	1	2	3	4	5
4	I am very familiar with developing 3 dimensional lessons	1	2	3	4	5
5	Within the last month I received recognition for work I have related to science teaching	1	2	3	4	5
6	I prefer to teach reading more than science	1	2	3	4	5
7	My students learn science for at least 30 minutes a day	1	2	3	4	5
8	I enjoy reading articles about science	1	2	3	4	5
9	Science is easy for students to learn	1	2	3	4	5
10	Within the last two weeks students designed an experiment or improved a design	1	2	3	4	5

11	Learning science is important for students	1	2	3	4	5
12	My students put forth effort in learning science	1	2	3	4	5
13	I have enough time during the school day to teach science	1	2	3	4	5
14	My students understand science concepts when I explain them to them	1	2	3	4	5
15	I can make learning science fun for students	1	2	3	4	5
16	Students have enough time to finish science assignments in class	1	2	3	4	5
17	I can use multiple ways to engage students in learning science	1	2	3	4	5
18	Majority of my students make good grades in science	1	2	3	4	5
19	I think it is important for students to express their views in science	1	2	3	4	5
20	Students often engage in discussion in science	1	2	3	4	5
21	My students can solve problems in science	1	2	3	4	5
22	Within the last two weeks students developed models in science.	1	2	3	4	5
23	Students have enough space to work on projects	1	2	3	4	5

24. In the past week my students participated in the following activities in science and/or math

Use Technology (chrome book or computer)	Yes	No
Conduct an experiment	Yes	No
Create a data table	Yes	No
Take observations and record data	Yes	No
Design something	Yes	No
Find a solution to a real-world problem	Yes	No

25. I believe most of my students can work in a science or engineering field as an adult. Yes or No

26. As an elementary educator how much time do you feel should be allocated to the following subject areas: (please answer in minutes of instruction)

Science: _________ Mathematics__________ Reading_________

Thank you for taking this survey!

Adapted from the North Carolina Friday Institute Teacher Efficacy and Attitude Toward STEM-Mathematics and Science (2012)

Appendix F

Teacher Mathematics Perception Survey

Teachers my feel they have varying degrees of readiness and expectations of math and science in elementary schools.

Directions: In this survey you will answer questions about you and what you think about math and science learning at your school.

About you.

School (Drop Down A or B)

Teacher (1-8)

Subject (Drop Down Math or Science)

Type of Instruction: Drop Down, Self-Contained, or Departmentalized)

Gender: (Drop Down: Male or Female)

Years Teaching Math or Science: (Drop Down: 0-3, 3-5, 5-10, 0-15, 15 +

I have a degree focused on: (Drop Down: math, science, math, and science, reading or other)

Please indicate your level of agreement or disagreement with each statement along the following scale.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Regarding Science and Mathematics learning in my classroom…

1	I enjoy teaching math	1	2	3	4	5
2	Teaching math is easy for me	1	2	3	4	5
3	I understand math concepts	1	2	3	4	5
4	I am very familiar with teaching common core math lessons	1	2	3	4	5
5	Within the last month I received recognition for work I have done related to teaching math	1	2	3	4	5
6	I prefer to teach reading more than math	1	2	3	4	5
7	I enjoy reading articles about math	1	2	3	4	5
8	Math is easy for students to learn	1	2	3	4	5
9	Within the last two weeks students used manipulatives in math	1	2	3	4	5
10	Learning math is important for students	1	2	3	4	5

11	My students put forth effort in learning math	1	2	3	4	5
12	I have enough time during the school day to teach math	1	2	3	4	5
13	My students understand math concepts when I explain them to them	1	2	3	4	5
14	I can make learning math fun for students	1	2	3	4	5
15	Students have enough time to finish math assignments in class	1	2	3	4	5
16	I think it is important for students to express their views in math	1	2	3	4	5
17	I can use multiple ways to engage students in learning math	1	2	3	4	5
18	Majority of my students make good grades in math	1	2	3	4	5
19	My students can work in a STEM area as adults	1	2	3	4	5
20	My math lessons will help students in their everyday experiences	1	2	3	4	5
21	Students often engage in math discussion	1	2	3	4	5
22	Within the last two weeks students-built math models	1	2	3	4	5
23	I prefer to teach reading more than math	1	2	3	4	5

24. In the past week my students participated in the following activities in science and/or math

Use Technology (chrome book or computer)	Yes	No
Conduct an Investigation	Yes	No
Create a data table	Yes	No
Analyze and record data	Yes	No
Design something	Yes	No
Find a solution to a real-world problem	Yes	No

25. I believe most of my students can work in a science or engineering field as an adult. Yes or No

26. As an elementary educator how much time do you feel should be allocated to the following subject areas: (please answer in minutes of instruction)

Science: _________ Mathematics__________ Reading_________

Thank you for taking this survey!

Adapted from the North Carolina Friday Institute Teacher Efficacy and Attitude Toward STEM-Mathematics and Science (2012)

Appendix G

Science and Mathematics Time on Task -Self Reporting Tool

School: **Teacher: (1-8)** **Subject:** Science
Hour/Section:

Minutes of Instruction: Record time in hour and minutes: Ex: Start time: 12:56 pm Stop time: 1:32pm

April/ May	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 2	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 3	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 4	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 5	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 6	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:

School: A or B **Teacher: (1-8)** **Subject:** Mathematics **Hour/Section:**

Minutes of Instruction: Record time in hour and minutes: Ex: Start time: 09:12 am Stop time: 10:30 pm

April/ May	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 2	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 3	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 4	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:
Week 5	Start Time:	Start Time:	Start Time:	Start Time:	Start Time:

	Stop Time:	Stop Time:	Stop Time:	Stop Time:	Stop Time:
Week 6	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:	Start Time: Stop Time:

Appendix H

School A NWEA GR 4 Mathematics & Science Assessment Scores

n	Mathematics	Science	Difference	D2
1.	168	188	20	400
2.	211	177	34	1156
3.	189	185	4	16
4.	190	185	5	25
5.	173	119	6	36
6.	173	179	6	36
7.	165	168	3	9
8.	203	205	2	4
9.	175	184	9	81
10.	199	190	9	81
11.	202	195	7	49
12.	170	164	6	36
13.	211	198	13	169
14.	189	191	2	4
15.	187	193	6	36
16.	198	202	4	16
17.	192	188	4	16
18.	191	189	2	4
19.	182	180	2	4
20.	175	188	13	169
21.	168	161	7	49
22.	190	183	7	49
23.	190	187	3	9
24.	190	187	11	121
25.	156	166	10	100
26.	193	180	13	169
27.	202	180	22	484
28.	181	176	5	25
29.	168	154	10	100
30.	190	191	1	1
31.	170	184	14	196
32.	178	164	14	196
33.	210	201	9	81
34.	168	188	20	400
35.	198	187	11	121
36.	156	166	10	100
37.	193	180	13	169
38.	181	176	5	25
39.	168	154	14	196

40.	190	182	8	64
41.	198	187	11	121
42.	156	166	10	100
43.	193	180	7	49
44.	181	176	5	25
45.	168	154	14	196
46.	178	164	14	196
47.	168	188	20	400
48.	190	182	9	81
49.	156	166	10	100
50.	193	180	13	169
51.	181	176	5	25
52.	170	184	14	196
53.	168	188	20	400
54.	190	182	8	64
55.	198	187	11	121
56.	156	166	10	100
57.	193	180	13	169
58.	181	176	5	25
59.	178	164	14	196
Sum n 59	Mean 182.32	Mean 179.00	Mean 9.77	Mean 94.09

Note: SPSS was used to analyze raw data for test statistics.

Appendix I

School B NWEA GR 4 Mathematics & Science Assessment Scores

n	Mathematics	Science	Difference	D2
1.	180	180	0	0
2.	185	191	6	36
3.	201	196	5	25
4.	199	187	12	144
5.	174	185	11	121
6.	204	178	26	676
7.	198	188	6	36
8.	211	204	7	49
9.	200	190	10	100
10.	166	192	26	676
11.	177	198	21	441
12.	192	189	3	9
13.	185	191	6	36
14.	199	187	12	144
15.	174	185	11	121
16.	204	178	26	676
17.	198	188	6	36
18.	199	187	12	144
19.	174	185	11	121
20.	204	178	26	676
21.	198	188	10	100
22.	194	188	6	36
23.	211	204	7	49
24.	177	198	20	400
25.	192	189	3	9
26.	199	184	15	225
27.	171	178	7	49
28.	166	185	19	361
29.	193	180	13	169

30.	191	169	22	484
31.	159	173	14	196
32.	202	198	4	16
33.	174	175	1	1
34.	195	181	14	196
35.	189	184	5	25
36.	167	164	3	9
37.	197	191	8	64
38.	187	190	3	9
39.	199	184	15	225
40.	171	178	7	49
41.	166	185	19	361
42.	193	180	7	49
43.	184	182	2	4
44.	201	196	5	25
45.	199	187	12	144
46.	174	185	11	121
47.	204	178	26	676
48.	145	169	24	576
49.	211	204	7	49
50.	200	190	10	100
51.	166	192	26	676
52.	177	198	21	441
53.	192	189	3	9
Sum n=53	Mean 188.08	Mean182.68	Mean 11.5	Mean 132.79

Note: SPSS was used to analyze raw data for test statistics.

Appendix J

K-12 Key NRC STEM Indicators to Monitor

Indicator No.	Description
1.	Number of, and enrollment in, different types of STEM Schools and programs in district and/or school
2.	Time allocated to teach science in grades K-5 at the district and/or school level
3.	Science related learning opportunities in elementary schools or schools' program
4.	Adoption of Instructional materials in grades K-12 that embody the common core state standards for mathematics and a framework for science K-12 education (NGSS)
5.	Classroom coverage of content and practices in the common core state standards for mathematics and a framework for science K-12 education (NGSS)
6.	Teachers' science and mathematics content knowledge for teaching
7.	Teachers' participation in STEM-specific professional development activities
8.	Instructional leaders' participation in professional development on creating
9.	Inclusion of science in federal and state accountability systems
10.	Inclusion of science in major federal K-12 education initiatives
11.	State and district staff dedicated to supporting science instruction.
12.	States use of assessments that measure core concepts of and practices of science and mathematics disciplines to include 3-dimensional science.
13.	State and federal expenditures dedicated to improving the K-12 system teaching workforce (District/School level)

14.	Federal funding for research identified in Successful K-12 STEM education (District/School level)

Note: Table created using information from NRC 2013 STEM Key Indicators Report. Descriptions have been modified to best support as a reference when used in addition to the Science and Mathematics Readiness Tool, Appendix A.

Appendix K

UMSL Education Department of Educator Preparation and Leadership

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INFORMED CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES

The Relationship Between Number of Instructional Minutes and Science and Math Achievement in Elementary School Settings

Participant ___________________________ HSC Approval Number ____________________

Principal Investigator Gwendolyn Randolph________ PI's Phone Number ______________

Summary of the Study

This project will determine the relationship if there is a relationship between time on task of science and mathematics and student achievement in elementary school settings. The participants are fourth grade students and staff. All participant engagement is remote access via online surveys and virtual meetings due to remote learning and coronavirus 19 protocols set forth by the district and midwestern state.

The duration of data collection is 5 weeks to include surveys and other data collection instruments. Students and staff will each complete a perception survey on science and mathematics. Assessment data will be a district assessment/benchmark in science and mathematics. The study procedures include purposeful sample of students and staff to participate in the research, preliminary verbal consent and overview of study to all participants, virtual meeting with building leaders, online surveys, data collection of surveys and performance data, and an administrator school readiness for science and math preparation tool for future interest or advance studies.

There are no foreseeable risks or discomforts for voluntary participation in the study. Reasonable expected benefits for students is voice in how they learn and potential interests to further the skill development in advanced courses in mathematics and science. Possible benefits for staff and school leaders is the ability to identify strengths and weakness of current math and science teaching and learning and assessment on time on task to learn math and science in elementary settings.

Alternative procedures in lieu of remote data collection procedures if applicable are face to face visits in lieu of sole remote learning conditions.

1. You are invited to participate in a research study conducted by Gwendolyn Randolph under the supervision of Dr. Charles Granger. The purpose of the research is to determine the correlation between time on task and student performance in mathematics and science in elementary school settings

2. a) Your participation as a teacher or building level administrator will involve:

   1) Taking an online teacher or building leader science perception survey. (< 20 min.)
   2) Taking an online teacher or building leader math perception survey. (< 20 min.)
      a. The science and math surveys (staff and student) are online questionnaires. The surveys will be sent to you within a three-day window for completion. You will have flexibility to complete the surveys at any time at your discretion during the three-day window. The survey will be sent the second-third week of June.
   3) Administering an online science and mathematics perception survey to your students. (25 min.)
      a. The student survey will be online and provided to students during the regular remote learning classroom period (math and/or science).
   4) Administering an online district criterion referenced-summative assessment to your students. (30 min)
   5) Gathering and submitting data on an online weekly time on task science and mathematics data collection log. (No more than 5-10 minutes daily or 10-15 min weekly)
      a. The log can be completed on a daily or weekly basis and updated via google document weekly. The log records the actual amount of time used for learning science and math instruction. The weekly time on task science and mathematics data collection will be monitored weekly by the principal investigator (Ms. Randolph)

- Building administrators will participate in an online meeting or telephone conference to complete or provide evidence of data collection to support science and math readiness instruction geared towards possible STEM integration. (20-30 min virtual meeting or teleconference)

Approximately 170 district staff and student participants may be involved in this research at the University of Missouri-St. Louis.

b) The amount of time involved in your participation: as a teacher (~110 minutes), as an administrator

140 minutes to include the following:

- Teacher data collection for a total of 5 weeks for recording time on task for math and science (weekly) (<15 minutes)
- Teacher/administrator completing science perception survey (< 20 min)
- Teacher/administrator completing math science perception survey (< 20 min)
- Teacher/ administrator providing student science and mathematics survey (25 min)
- Administrator meeting or telephone conference with PI for science and math readiness data collection tool (< 30 min)
- Student participation in district math/science summative assessment (30 min)

3. There are no known risks associated with this research.
4. The possible benefits to you from this research are your opinions and voice regarding teaching and learning of science and mathematics at your grade level and research data on the amount of time students receive and/ or need to learn math and science in elementary schools. Other possible benefits are a set of data to support or enhancing a more science, math, technology or engineering schoolwide focus or program.
5. Your participation is voluntary, and you may choose not to participate in this research study or withdraw your consent at any time. You will NOT be penalized in any way should you choose not to participate or withdraw.
6. We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication that may result from this study. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research Protection) that would lead to disclosure of your data as well as any other information collected by the researcher.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Ms. G. Randolph or the Faculty Advisor, Dr C. Granger. You may also ask questions or state concerns regarding your rights as a research participant to the Office of Research, at 516-5897.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I hereby consent to my participation in the research described above.

______________________________	______________________________
Participant's Signature	Date
______________________________	______________________________
Signature of Investigator or Designee	Date

Appendix L

UMSL Education Department of Educator Preparation and Leadership

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ASSENT TO PARTICIPATE IN RESEARCH ACTIVITIES (MINORS)

The Relationship Between the Number of Instructional Minutes (Time on Task) and Science and Mathematics Student Achievement in Elementary School Settings

Dear Student,

1. My name is Ms. G. Randolph

2. I am asking you to take part in a research study because we are trying to learn more about how students in your grade feel about learning science and math in elementary school.

3. If you agree to be in this study, you will participate in an online science and math survey that will take no more than 20 minutes to complete and allow me to use and analyze test data from the district math and science assessment.

4. There are no risks to you if you participate in the research.

5. Your benefits of participating in this research is an opportunity for you to express how you feel about your remote learning in science and mathematics and to help guide teachers and administrators on how to better help you to learn science and mathematics at your school.

6. Please talk this over with your parents before you decide whether to participate. I also will ask your parents to give their permission for you to take part in this study. Even if your parents say "yes," you still can decide not to do this.

7. If you do not want to be in this study, you don't have to participate. Remember, being in this study is up to you, and no one will be upset if you do not want to participate or if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you did not think of now, you can call me or ask me next time you see me.

9. Signing your name at the bottom means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it. All responses you provide will remain confidential in accordance with the study.

____

____

Participant's Signature Date

Participant's Printed Name

____

____

Parent or Guardian's Signature Date

Parent or Guardian's Printed Name

_______________ __________________

Participant's Age Grade in School