PERCEPTIONS OF PRINCIPALS IN A SCIENCE AND MATHEMATICS PROFESSIONAL DEVELOPMENT PROGRAM

by

Sara M. Hanson, B.S.

A thesis submitted to the Graduate Council of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Science in Interdisciplinary Studies
with a Major in Interdisciplinary Studies
May 2019

Committee Members:

Sandra West, Chair

Sandra Browning

Emily Summers

Julie Westerlund

FAIR USE AND AUTHOR'S PERMISSION STATEMENT

ACKNOWLEDGEMENTS

I feel so honored, grateful, and lucky to be in this place at this time. I could never have made it to this point if it were not for my grandparents, Nama and Poppie. Thank you for everything you have done to support me, I am eternally grateful.

I would like to say another big thank you to my mother, my Ammitt, Bryant, Terry, Jess, and every other family member and friend that supported me throughout this journey. They have given their time, love, and support again and again.

Finally, I would like to acknowledge my committee for all of their long hours, patience, and flexibility as I worked my way through this new process. Dr. West spent countless hours mentoring me and guiding me through learning all of the aspects of research, which were so very foreign to me. Dr. Summers provided me with clear and regular feedback with her expertise in methodology, helping me to clarify my work. Dr. Browning is an amazing mathematics expert (I smile as I write mathematics) and I have learned so much by watching her action. Dr. Westerlund came into my committee later in the writing process, but embraced it and jumped in to help me when needed. By working with these experts, being in their classes, and participating in *Mix it Up,* I have gained so much that I have already been able to implement in my own classroom.

I am eternally grateful to all that helped me in my process in any way. Sincerely, thank you.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATIONS

Abbreviation	Description
AAAS	American Association for the Advancement of Science
CCSSM	Common Core State Standards for Mathematics
CSM	Correlated Science and Math
NCTM	National Council of Mathematics
NGSS	Next Generation Science Standards
NRC	National Research Council
NSF	National Science Foundation
STEM	Science, Technology, Engineering, and Mathematics
STL	Science Teacher Leader

I. INTRODUCTION

The need for qualified individuals to fill positions in science, technology, engineering, and mathematics (STEM) careers has increased the attention on STEM education over the last decade. In a National Science Foundation's (NSF) 2007 report, the authors stated that the United States, although the most "technologically capable economy in the world" is "failing to ensure that all American students receive the skills and knowledge required for success in the 21st century workforce" (NSF, 2007, p. 1). Therefore, a greater need than ever exists to ensure that students have a deeper understanding of science and mathematics (Gonzales et al., 2009).

STEM is a broadly used term, not defined officially but used to describe various ways that science, technology, engineering, or mathematics is used, taught, or discussed. STEM can include all four of the disciplines together, each of the disciplines as separate entities, or two or more of the disciplines combined in some manner. The vague, undefined, and open-ended term of STEM is broadly used in most of today's references on science, mathematics, engineering. or technology as can be seen in the broader context of relevant general public as well as professions discussions and literature review.

The focus of my particular study, however, was only on science and mathematics. The term *science/mathematics* was used throughout the paper to refer to either science or mathematics, as some participants taught science and others taught mathematics. It was referred to as science *and* mathematics when it was regarding the integration of science and mathematics subjects.

The Connection Between Inquiry and Science and Mathematics

The scientific and science education community have long emphasized the need for students to understand the patterns in the natural and material world through scientific inquiry and the use of empirical evidence. The authors of the *National Science Education Standards* (National Research Council, [NRC], 1996) emphasized the importance of scientific inquiry in kindergarten through twelfth-grade education. Scientific inquiry is a fundamental aspect of science education, as it allows students to develop a more in-depth understanding of scientific principles (Bybee, 2000).

Multiple researchers have provided evidence that using inquiry-based learning in science classrooms is an effective form of instruction for helping students to develop these deeper understandings of scientific concepts (Anderson, 2002; Krajcik, Blumenfield, Marx, & Soloway, 2000; Von Secker, 2002). The *National Science Education Standards* (NRC, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, [AAAS], 1993) both recommended that students should be actively engaged in asking their own questions, selecting and designing investigations to answer their research question, and finding answers as recommended in *A Framework for K-12 Science Education* (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013).

Students collect and organize their data through measuring and counting, graphing their data, and forming conclusions that explain their findings. Students who understand and explain their findings are more likely to understand and explain other phenomena and make predictions. While not all student scientific research data are empirical, most scientific data are empirical. Moreover, science highly values the use of mathematics in science inquiry to quantify and analyze data. Young children as early as kindergarten begin to quantify data, where students are describing observations in quantities such as frequency or size measurements. Thus, we see the early and ongoing use of mathematics as a foundational tool for scientific inquiry.

Connecting Science and Mathematics

The rich use of mathematics in scientific inquiry provides abundant evidence to support the idea that integrating the two subjects more deliberately in the classroom to enhance deeper understanding of both disciplines makes sense. Creating both deeper and more extensive relationships between mathematics and science has been recommended by authors of both the NGSS (NGSS Lead States, 2013) and the *Common Core State Standards for Mathematics* (CCSSM) (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Among many others, benefits of integrating science and mathematics instruction include achieving a deeper understanding of science concepts (McBride & Silverman, 1991; West & Tooke 2001; West & Tooke, 2003; West & Vasquez, 2006; West, Vasquez-Mireles & Coker, 2006; Vasquez-Mireles & West, 2007). Providing concrete examples of abstract mathematical ideas as well as achieving a deeper understanding of mathematics concepts by providing an application allows students to make connections between mathematics and science concepts on their own (Peters, Schubeck & Hopkins, 1995).

Problems in Connecting Scientific Inquiry and Mathematics

Even though national science and mathematics standards support the use of scientific inquiry in the classroom, if inquiry-based, hands-on science lessons are not actually taking place in science classrooms, it could be attributed to the fact that science teachers themselves have had little experience with authentic inquiry-based learning. If teachers have not experienced effective, authentic scientific inquiry themselves, they will likely have a more difficult time being able to choose and implement successful inquiry-based science lessons in their classroom than if they had experienced it themselves. There is also a problem of confusing inquiry with *hands-on*. While *hands-on* is consistent with inquiry experiences, *hands-on* or concrete, including kinesthetic, experiences, are also needed in other instructional models such as direct-instruction (Van de Walle, Karp, & Bay Williams, 2016; Pashler, McDaniel, Rohrer, & Bjork, 2008).

The emphasis on the improvement of the quality of science and mathematics curricula and instruction has encouraged education reform advocates to find more effective approaches to teaching science and mathematics. These include utilizing professional development opportunities and other programs to address the needs of pre-service and in-service teachers and provide them with authentic scientific inquiry learning opportunities (Crawford, Zembal-Saul, Munford, & Friedrichsen, 2004; NRC, 2000).

The Role of the Principal in Improving Science/Mathematics Literacy

The urgency to create individuals who are scientifically, technologically, and mathematically literate drives the need for teachers to integrate science and mathematics as they implement effective inquiry-based instruction. However, although most research focuses on teachers as the main agents of change in improving science practices, the authors of *Benchmarks for Science Literacy* (AAAS, 1993) make it clear that teachers cannot be held responsible for achieving reform on their own and that administrators must support teachers' efforts (AAAS, 1990). While studies have been conducted on the influence of content-integration professional development on in-service teachers (Austin et al., 1992; Basista & Matthew, 2002; Basista, Tomlin, Pendleton, & Pugh, 2001), my study explored the perceptions of teachers and their principals who were attending a professional development program focused on improving the integration of science and mathematics in classrooms.

Statement of the Problem

The literature review below highlights the need for quality science and mathematics education, specifically the integration of science and mathematics in the classroom. Professional development can be utilized to better enable teachers to employ best practices in their science and mathematics teaching. However, effective professional development must adhere to best practices. Moreover, studies have shown that teachers are more likely to utilize learning from professional development and more effectively implement strategies and approaches gained during attendance if they have the support of their principal (Banilower, Heck, and Weiss, 2007; Sandholtz, and Ringstaff, 2016).

My study examined the level and effectiveness of the science/mathematics support that principals provided, as perceived by both teacher and principal participants in a science and mathematics professional development program. In the past, data from teacher participants have been collected and analyzed to examine the influence of a science and mathematics professional development program on teachers integrating science and mathematics in their classrooms. However, little data have been collected that identify teachers' and principals' perceptions of principal-provided science/mathematics support when the principal attends a science and mathematics-specific professional development program with the teachers at their campuses.

Statement of the Purpose and Research Questions

The purpose of this study was to examine teachers' and principals' perceptions of the role of principals and the support they provide teachers while attending a science and mathematics-specific professional development program for fifth-grade through eighth-grade science/mathematics teachers and principals. In my study, I examined teachers' and principals' perceptions of principals' roles as science/mathematics leaders and principals' actions in supporting teachers at their campuses in science/mathematics instruction. I identified the following research questions to address the purpose of this study as stated above:

(1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?

(2) What were teachers' perceptions of the science/mathematics support provided by their principal?

(3) How did principals perceive themselves in the role of a science/mathematics principal leader?

(4) What were principals' perceptions of their support of teachers in science/mathematics instruction?

Theoretical Framework

With the goal of this science and mathematics professional development being to impact participants' use of effective science/mathematics teaching strategies, it would be beneficial if participants had positive experiences with effective science/mathematics teaching strategies themselves as they learned mathematics and science. According to constructivist (Vygotsky, 1978) and constructionist (Papert, 1991) theories, learning takes place through observation and experience. These theories stated that through reflection of experiences and observations, learners construct their own understandings. Therefore, in order for principals to more fully understand what constitutes effective science or mathematics instruction, principals should experience first-hand, quality science/mathematics teaching and learning themselves.

The proposition in my study states that, with a constructivist and constructionist approach, principals' experiences gained through participation in quality professional development with the teacher teams will lead to principals being more aware of effective principal-provided science/mathematics support. The knowledge gained through a quality professional development will better equip principals to provide more appropriate and effective support in their teachers' efforts to utilize science/mathematics best practices and improve science/mathematics instruction and learning on their campuses.

Context of the Study

The professional development program used for this study was a Teacher Quality grant-funded program called *Mix it Up*. The *Mix it Up* professional development program utilized the Correlated Science and Math (CSM) model (West & Tooke, 2001; West & Vasquez, 2006) as a means to enable teachers to more deeply understand science and mathematics and to create and teach integrated science and mathematics instruction in their classrooms. This program was directed at linking mathematics and science in a unique CSM professional development model to improve science/mathematics instruction specifically in the fifth through eighth grades. The professional development program included two weeks (a total of 70 hours) of summer training for teachers as well as a seven-hour teacher training that took place on Saturdays once a month throughout the school year. *Mix it Up* incorporated principals by recruiting teams of science and mathematics teachers and their principals.

Principals committed to attending a two-day (16 hour) summer principals-only training designed to enable principals to develop a deeper understanding of science/mathematics best practices. Principals also agreed to attend at least one Saturday training with their teacher teams each semester during the school year, learning science/mathematics content and pedagogy and how to integrate both disciplines in classrooms. Principals were also encouraged to attend as many additional trainings and on-site learning visits with the teacher teams as possible.

II. LITERATURE REVIEW

The literature review below highlights studies conducted in the area of science and mathematics integration, science and mathematics best practices, and the need for quality professional development. My literature review also examined principals' influence on teacher success in general. However, I found a lack of research in the area of principal participation in a science and mathematics professional development program and the influence on the support that principals provide their teachers.

Science and Mathematics Integration

One of the primary approaches advocated by science and mathematics education reform supporters is teaching subjects in a more integrated manner. The NGSS (NGSS Lead States, 2013) and the CCSSM (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), both widely accepted in their respective fields, have recommendations for building deeper connections between mathematics and science.

Bosse, Lee, Swinson, and Faulconer (2010) outlined the similarities between the National Council of Teachers of Mathematics (NCTM) (NCTM, 2000) process standards and the NRC (NRC, 1995) 5E lesson model and argued for the integration of mathematics and science to improve student learning in both subjects. Park Rogers, Volkmann, and Abell (2007) reported that mathematics could be particularly useful in science when organizing information into graphs and tables. They explained that by examining patterns within the data, a deeper understanding of the information could be obtained. They also argued that science could provide concrete representations of abstract mathematics ideas. Finally, they argued that students benefit when connections between science and mathematics are made explicit.

Offer and Mireles (2009) explored the benefits that teachers experienced when integrating science and mathematics in their classrooms. Some benefits of connecting science and mathematics in the CSM professional development model noted by West & Vásquez-Mireles (2006) and Vásquez-Mireles & West (2007) included connections between mathematics and science in different ways. The CSM model clarified that classroom integration of science in a mathematics classroom can occur when (1) science data that is collected in the science classroom is analyzed in the mathematics classroom, (2) science academic vocabulary is used correctly in the mathematics classroom, (3) science equipment is used in the mathematics classroom, and (4) content from the science classroom is referenced in the mathematics classroom. Conversely, the CSM model defined classroom integration of mathematics in the science classroom when (1) mathematics is used in the science classroom, (2) mathematics academic vocabulary is used correctly in the science classroom, (3) mathematics manipulatives are used in the science classroom, and (4) content from the mathematics classroom is referenced in the science classroom.

Effective Science and Mathematics Teaching and Best Practices

Researchers have long recommended student-centered classrooms, including a shift from *teacher as instructor* to *teacher as a facilitator*, more student choice and responsibility, focus on more in-depth content rather than breadth of content, and an emphasis on learning rather than a score (Butler, 2012). In order to utilize exemplary teaching methods, teachers must have subject-matter knowledge and pedagogical knowledge, as well as specific pedagogical content knowledge (Anderson, 2002). These different types of knowledge are foundational when attempting to successfully integrate science and mathematics in a classroom. However, if the goal is to integrate science and mathematics, the question becomes how much of each discipline's content and content pedagogy is necessary for attainment.

The Need for Quality Professional Development

Although teachers may exit their teacher education programs with specific subject-matter knowledge as well as pedagogical knowledge, they cannot be expected to be experts in every content area. Therefore, quality professional development is needed to address teachers' content knowledge in science and mathematics as well as their pedagogical content knowledge, specifically their understanding of implementing integrated mathematics and science (Basista & Mathews, 2002). Further, Havice, Havice, Waugaman, and Walker (2018) asserted that effective STEM-specific professional development can give teachers a greater knowledge of integrative STEM concepts which can improve teachers' confidence levels as well as their ability to implement inquiry-based STEM lessons.

Herrington and Daubenmire (2016) clarified that quality professional development must last longer than one day. They explained that professional development is an investment of time and resources so that teachers can benefit from a meaningful learning community. Garet, Porter, Desimone, Birman, and Yoon (2001) examined best practices in professional development and identified the following best practices: sustained and intensive professional development, focus on content knowledge, coherence or integration into daily school life, and active, hands-on learning.

The CSM professional development model incorporated several of the recommended practices in the long term and intensive *Mix It Up* project. Science and mathematics teacher teams in the program were asked to commit to attending two years of professional development with over 100 hours, while their principals committed to attending at least 24 hours. Intensive instruction of both mathematics and science content and pedagogy occurred regularly throughout the training. The teacher morning sessions focused on science content and pedagogy and the integration of the mathematics. The afternoon sessions' focus was on mathematics content and pedagogy used in the science instruction.

Influence of Principal Support on Teacher Success

Even equipped with first-hand knowledge and experience with effective science and mathematics teaching strategies, teachers are faced with obstacles that can still stand in the way of attempts to implement integrated science and mathematics in their classroom. One of the biggest obstacles can be lack of principal support. Banilower, Heck, and Weiss (2007) conducted an in-depth study on the impact of a particular science professional development program on teachers. They found a positive relationship between perceived principal support and the amount of time teaching science, as well as increased use of designated instructional materials and investigative strategies from the program. Banilower et al. suggested that when teachers feel supported in using what they gain from professional development, they will use the strategy learned more often.

Sandholtz, and Ringstaff (2016) obtained similar findings in their longitudinal study examining the factors influencing the sustainability of science instruction two and three years after attending professional development. They found that principals played a major role in either facilitating or hindering science instruction in kindergarten through second grades due to principal provided expectations, curriculum guides, resources, and time given to teachers to collaborate. Sandholtz and Ringstaff's study emphasized the role of the principal in sustaining science instruction over time.

Wenner (2017) looked at science teacher leaders (STLs) that included STEM specialists and coaches who worked with teachers to close the gap in science achievement. Of the characteristics identified as supportive for STLs, roles and relationships, the key characteristic was positive relationships with the principal. Positive relationships included consistent communication with the principal regarding materials, goals, and issues experienced by the teacher. School culture and context also played an important role in whether or not STLs felt supported in their efforts. Successful STLs felt that their school culture was a shared vision that appreciated science and mathematics education and was a place where collaboration and continued improvement of teaching practices were valued. Another common perception of support among successful STLs was the ability, specifically the time and money, to attend professional development specific to their needs. Finally, the need for science materials was a common theme among STLs.

Wenner's findings outline the importance of principal support in teachers effectively utilizing what they gain from attending professional development. Carver (2010) suggested that principals, themselves, receive specific benefits from attending professional development in content. In Carver's study, selected principals attended a professional development training over five months where they experienced what it was like to be a learner of Algebra. They spent time problem-solving in the same manner as their students, watching expert teachers in action, and analyzing student work. Results showed that principals that attended the professional development were better observers in Algebra classrooms, as they had a better idea of what they should expect to see and hear in an effective Algebra classroom.

In recent years, multiple studies have examined the contextual variables that influence teachers' confidence and ability to implement effective science and mathematics instruction in their classrooms. Many contextual factors were found to positively influence a teacher's implementation of effective science and mathematics. These factors included: time to collaborate and plan, content and pedagogical support, science and mathematics-specific teacher professional development opportunities, access to resources, a supportive STEM culture, and communication among departments (EL-Deghaidy, Mansour, Alzaghibi, & Alhammad, 2017; Knipprath, Thibaut, Dehaene, & Depaepe, 2018; Shernoff, Sinha, Bressler, & Ginsburg, 2017). All the factors listed were issues with which principals had influence, therefore would fall under the category of principal support. Principal support specific to STEM has been shown to positively influence teachers' confidence, which then influenced their engagement in STEM teaching (Dong, Xu, Song, Fu, Chai, & Huang, 2019). In a 2018 study that examined components of successful STEM-policy implementation in a STEM-focused school district, Icel (2018) stated that administrative support is the "fuel of the policy engine" and that professional development is the "pulse of successful implementation" (p. 10).

Summary of Current Literature

The above literature highlights the need for quality science and mathematics education, specifically the integration of science and mathematics in the classroom.

Professional development is an approach used for teachers to learn the best practices needed to improve science and mathematics instruction. However, quality professional development must adhere to best practices established for professional development. Multiple studies support the idea that teachers are more likely to utilize learning from professional development and more effectively implement strategies and approaches gained during attendance if they have the support of their principal. Finally, benefits seem to exist when principals attend content professional development themselves.

III. METHODOLOGY

In my study, I examined teachers' and principals' perceptions of principals' roles as science/mathematics leaders and principals' actions in supporting teachers at their campuses in science/mathematics instruction. I identified the following research questions to address the purpose of this study as stated above:

(1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?

(2) What were teachers' perceptions of the science/mathematics support provided by their principal?

(3) How did principals perceive themselves in the role of a science/mathematics principal leader?

(4) What were principals' perceptions of their support of teachers in science/mathematics instruction?

Setting

For the setting of my study, I used the trainings provided by the *Mix it Up* professional development program. *Mix it Up* was a Teacher Quality grant-funded program that utilized the Correlated Science and Math (CSM) model (Vasquez-Mireles & West, 2007) as a means to enable teachers to more deeply understand science and mathematics and to create integrated science and mathematics instruction in their classrooms. This professional development program was directed at integrating science and mathematics to improve science/mathematics instruction, specifically in the fifth through eighth grades.

Teachers and principals attended the professional development primarily at a large southwestern university, as well as different sites around Central Texas for on-site learning visits. The program included two weeks (a total of 70 hours) of summer training for teachers as well as a seven-hour training that took place on Saturdays once a month throughout the school year. Principals attended a two-day summer training that was specific to principals and were also asked to join their teachers for at least one Saturday training per semester.

Participants

In table 1, I organized participant information with pseudonyms. My study included seven teacher participants from three different districts. Three teachers taught fifth grade. One of the fifth-grade teachers taught mathematics, one taught science, and one was a general education teacher who taught both science and mathematics. Two teachers taught seventh grade. These two teachers were at the same middle school and were a team, where one taught mathematics and the other taught science. Finally, two teachers taught a mix of seventh and eighth grades at the same middle school. This duo of teachers was also a team, with one teaching science and the other teaching mathematics.

Principal participants included six principals from three different school districts. Four were elementary principals and from the same school district as the fifth-grade teacher participants. One elementary principal did not have any teachers at their campus participate in my study. Also attending were two middle school principals from two different school districts. Each of the middle school principals had a team with one science and one mathematics teacher at their campus.

Table 1

Principals and Teachers Included in the Study

Principal Participants	Teacher Participants	Teachers' Grade Levels	School Name	School District Name
Brenda Alvarez	Samantha Austin	5th	Georgia Elementary	Luna School District
Penelope Fitzgerald	Wendy Barilla	5th	Blanton Elementary	Luna School District
Seth Gibson	Debra Addams	5th	Grazier Elementary	Luna School District
Sarah Stratton	n/a	n/a	Carris Elementary	Luna School District
Milton Myers	Sean Brady	7th	Pine Middle School	Pearl School District
	Trent Tyler	7th	Pine Middle School	Pearl School District
Terence Richards	Isabel Martez	7th/8th	Krispin Middle School	Meadows School District
	Shannon Cordova	7th/8th	Krispin Middle School	Meadows School District

Sampling

I chose the participants in my study because of their pre-established, voluntarily involvement with the *Mix it Up* professional development program. Therefore, all six principals and seven teachers previously agreed to be a part of the program and agreed to the minimum attendance requirements of 70 hours for teachers and 24 hours for principals. I followed protocols under *Mix it Up's* Instructional Review Board approval number 2016W4728 and later my own IRB number Instructional Review Board approval number 2018643 to increase confidentiality. Ultimately, one principal did not participate in the study. The teacher at their campus was still included because of her participation.

Sampling of teacher participants. I used criterion-based sampling in all aspects of my study because all of the participants were a part of the *Mix it Up* professional development program. To address the first research question regarding participants' perceptions of what constitutes the role of an effective science/mathematics principal, I wanted as many different perspectives from participants as possible. I included all teacher participants that attended a particular training during the *Mix it Up* program, whether their principal had been included in the overall study or not. In this sense, I also used convenience sampling because the teachers that were present at this particular training were the participants I used to help answer the first research question.

With the second research question, I wanted to analyze teachers' perceptions of the support that their own principals provide as science/mathematics leaders. Therefore, I used criterion-based sampling to choose the participants to share their perceptions about the support that their principals provided in regard to science/mathematics instruction. I chose to include only the teachers in the program that attended the summer training in 2016 as well as had a principal that had agreed to be included in the study. In this way, I was able to examine not only how principals perceived their own actions, but also how teachers perceived these same principals' actions in supporting science/mathematics instruction.

Sampling of principal participants. To address the third and fourth research questions that focused on how principal participants perceived themselves in the roles of science/mathematics principals and the support that they saw themselves providing teachers at their campus, I gathered principal participants to give their perspectives. To choose participants, I used criterion-based, maximum variation sampling. Using the maximum variation sampling approach, I determined specific criteria to maximize the differences in participants' experiences to increase the likelihood that the results would reflect different perspectives. I included all principals that attended the principal training in the summer of 2016.

Research Design

For my research design, I implemented a mixed methods research approach using a concurrent convergent triangulation design (see Figure 1 below). A mixed methods approach allows the researcher to utilize both qualitative and quantitative data collected throughout the study (McMillan, 2012). Utilizing mixed methods allowed me to benefit from the strengths of each method to form a more complete picture. With my study aiming to describe the science/mathematics principal and principal-provided science/mathematics support perceived by teachers and principals, a mixed methods approach best matched my goals, as it allowed me to build a more thorough understanding of the phenomenon being explored.

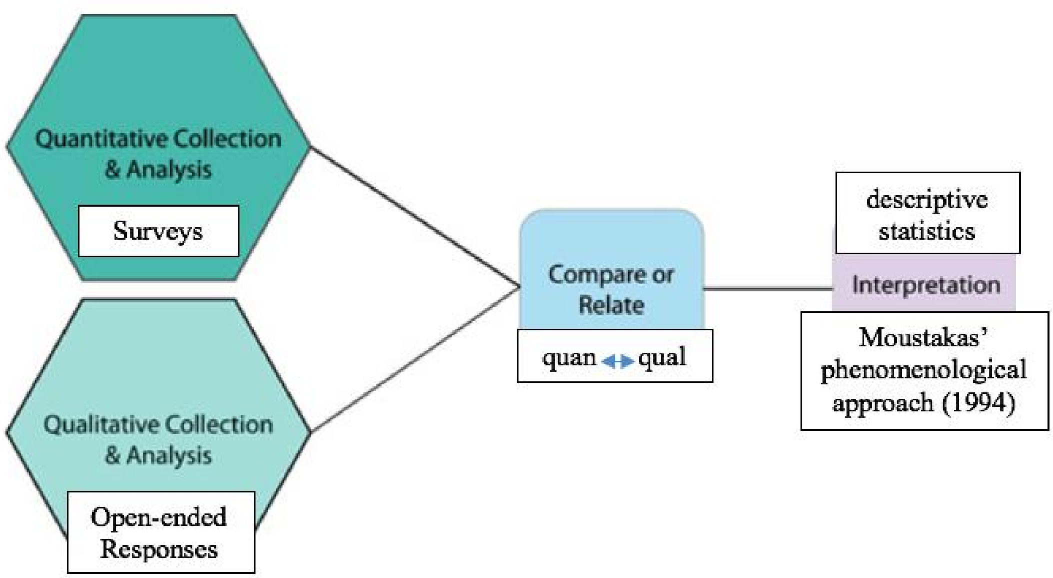

Figure 1. Concurrent convergent parallel design (Creswell & Poth, 2018).

Qualitative Research Design

For the qualitative portion of my study, I utilized a phenomenological research approach. With a phenomenological approach, the researcher aims to discover the common meaning of a phenomenon or concept through the lived experiences of individuals (Moustakas, 1994). This approach matched best with the goals of my study. My study aimed to provide a composite description of the common experiences that participants, both principals and teachers, described in terms of the science/mathematics principal. The aim of my particular study was to describe the science/mathematics principal by using the shared experiences of the participants in the *Mix it Up* program. In my study, I provided a composite description of the common experiences that participants, both principals and teachers, described in terms of the science and mathematics principal. Staying within the framework of Moustakas' phenomenological approach, the descriptions used focused on the *what* and the *how* of the experience. More specifically for my study, the descriptions focused on perceptions regarding the role of the principal as a science/mathematics leader and the support provided to teachers by the principal to enhance science/mathematics instruction.

Several features helped to define phenomenological studies (Moustakas, 1994). These defining features included an emphasis on a particular phenomenon to be explored. In the case of my study, the particular phenomenon was the science and mathematics principal. Participants described their view of their science and mathematics principal and the support they provided.

Another defining feature was using a heterogenous group of participants who have all experienced the phenomenon. In my study, both principals and teachers who participated in the *Mix it Up* program and interacted with or actually were principals were included. These shared experiences came together to provide a composite description of the phenomenon of the science and mathematics principal.

Bracketing was a final key feature of phenomenology that I used to set the researcher's personal feelings and experiences apart from the study (Creswell & Poth, 2018). As the researcher is working closely with participants or is particularly invested in the program being studied, bracketing must be utilized to stay as objective as possible. While removing my feelings and experiences from the study completely may be implausible, I strived to not allow my own feelings and experiences to be engaged when conducting the study.

Quantitative Research Design

Because descriptive statistics help the researcher to summarize a set of numbers in order to communicate the characteristics of the data (McMillan, 2012), I chose to use descriptive statistics for the quantitative portion of my study. I utilized Excel to run analyses and display results. The statistics I focused on were frequency and percentages. (Pazaglia, Stafford, & Rodriguez, 2016). Straightforward summary statistics help the researcher and audience to clearly see and understand the variation in responses provided by participants.

Table 2 relates the research questions with the qualitative and quantitative data sources I used in my study. Both the Principal's Perceptions Inventory and the Teacher's Perceptions of Principals' Practices utilized open-ended, free response questions, as well as close-ended, Likert-scale type numerical responses. The Principal's Role Survey contained only open-ended response questions.

Table 2

Summary of Research Questions with Qualitative and Quantitative Data Used

Research Question	**Qualitative Data**	**Quantitative Data**	**Data Source Used**
(1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?	Open-ended Responses	None collected	Principal's Role Survey
(2) What were teachers' perceptions of the science/mathematics support provided by their principal?	Open-ended Responses	Likert-scale responses	Teachers' Perceptions of Principals' Practices
(3) How did principals perceive themselves in the role of a science/mathematics principal leader?	Open-ended Responses, Vignettes	None collected	Principals' Perceptions Inventory (Parts II and III)
(4) What were principals' perceptions of their support of teachers in science/mathematics instruction?	Open-ended Responses	Likert-scale responses	Principals' Perceptions Inventory (Part I)

Ethical Considerations

I considered ethical implications while designing and conducting my study. By upholding Instructional Review Board approval number 2018643, I increased protection of participants in the *Mix it Up* program. As participants began the *Mix it Up* professional development program, they all completed informed consent forms. Participation in the program was completely voluntary and all data collected was kept confidential. I also gave all participants pseudonyms to keep their identities confidential throughout the study. Project coordinators of the *Mix it Up* program also increased protection to participants under Instructional Review Board approval number 2016W4728.

Methodological Rigor

Methodological rigor manifests itself differently with different research design approaches. Table 3 compares the differences in terminology used to address quantitative research versus qualitative research. My study utilized a mixed methods research design; therefore, I considered all the aspects in the table below while establishing the rigor of my methods to build validity and trustworthiness.

Table 3

Criteria for Judging the Rigor of a Research Study: Quantitative and Qualitative Terms

Aspect	Quantitative terms	Qualitative terms
Truth value	Internal validity	Credibility
Applicability	External validity or generalizability	Transferability
Consistency	Reliability	Dependability
Neutrality	Objectivity	Confirmability

Source: Adapted from Lincoln and Guba (1985).

Quantitative Strategies to Establish Rigor

Strategies that can be used to establish rigor in quantitative studies that are listed in Table 3 include internal validity, external validity or generalizability, reliability, and objectivity (Lincoln & Guba, 1985). With my study being a thesis, constraints included time and budget. However, I did make attempts to establish rigor in the quantitative portion of my study.

Internal validity. Whereas the aspect of truth value is referred to as *internal validity* in quantitative methods, qualitative methods uses the term *credibility*. I used content validity to ensure that one of my instruments completely covered the content. To achieve content validity, I asked experts in the field to give their opinion regarding the level to which the instrument measured the concept intended and make any suggestions. Their feedback was included in the final version to improve the validity of the instrument. I was not able to establish additional types of validity with my quantitative instruments. Because so little research done had been done in this particular area, similar validated instruments were not available to compare with my researcher-created instruments.

External validity or generalizability. What is referred to as *transferability* in qualitative studies is known as *external validity* or *generalizability* in quantitative studies. Both represent the idea of applicability, which is how the results can be applied to other situations and populations. The biggest potential threat to external validity in my study is lack of generalizability to a larger population due to small sample and project size. This one study, with its small sample size, cannot be used to inform decisions but may provide rationale for further studies in the area.

Reliability. The aspect of consistency is expressed as *reliability* in quantitative methods, but is referred to as *dependability* in qualitative methods. In regard to instrument reliability, I administered the instruments only once due to the time constraints of this being a thesis study. Also, this study is not able to be easily replicated due to the specific nature of the *Mix it Up* program as well as the fact that this particular program has now ended. However, additional studies could be conducted in the same area to further explore the role of the science/mathematics principal and the support that they provide teachers.

Objectivity. Finally, the idea of maintaining neutrality throughout the study is described as *confirmability* in qualitative methods, while it is called *objectivity* in quantitative methods. Objectivity may be more easily attained in quantitative methods, as they are intended to obtain summaries of data and require less interpretation of the results. I was able to easily remain objective as I tallied the numerical results of the quantitative portions of my data collection instruments.

Qualitative Strategies to Establish Rigor

I used many different strategies to help establish rigor in the qualitative portion of my study. Qualitative strategies I used were meant to enhance credibility, transferability, dependability, and confirmability. Because I took more qualitative data than quantitative data throughout the study, I used qualitative strategies as the principal means of establishing rigor in my study.

Credibility. In my study, I established trustworthiness, a component essential to phenomenological studies, through multiple techniques. I strived to maintain credibility through triangulation, the use of disconfirming evidence, and prolonged exposure in the field (Creswell, 2014). I used triangulation of qualitative data sources by comparing the perspectives of principals' perceptions of principal support with teachers' perceptions of the same principals' support to see if they have similar descriptions. Also, I integrated both quantitative and qualitative data sources addressing the same topics to provide a more complete picture of the issue I addressed. I also employed triangulation through the use of multiple analysts. Researchers vested in the *Mix it Up* program also analyzed data related to principal support. The use of triangulation allowed me to enhance credibility by reducing bias and misrepresentation as well as by demonstrating that the findings were not simply a result of one method, source, or analyst.

Another method to build credibility was the search for and the use of *disconfirming evidence*. In my study, I sought to find and include any evidence available, even if it contradicted the pattern found. By including this type of evidence, it made the study more realistic and plausible.

Finally, I used my prolonged exposure in the field to build credibility. With prolonged exposure with participants in the *Mix it Up* program, I was able to develop an understanding that was more in-depth than if I had not had those experiences with participants in the field. I do believe that *Mix it Up* improves science/mathematics instruction in schools. However, because of my role as a researcher, it was essential that I utilized bracketing to keep my own personal feelings and experiences apart from the study as much as possible. Moustakas (1994, p. 33) explained that when utilizing the perspective of *epoche*, that "the everyday understandings, judgements, and knowings are set aside, and the phenomena are revisited". My intention was that by keeping my own experiences in *epoche*, my personal feelings would not influence the results of the study.

Transferability. While *generalizability* refers to generalizing the results to and among other populations in quantitative work, *transferability* is generally obtained in qualitative studies through the use of thick, rich description. The use of rich, thick description helps the results to seem more realistic and can offer many perspectives, which helps to add to the transferability of the results (Creswell, 2014). When fully describing the *what* and *how* of the experience (Moustakas, 1994), rich description was an inherent component of phenomenology. However, keeping findings in the context of the purpose of the study was essential to the analysis. Comparing findings against the data helped me to ensure that the analysis did not become separate from the purpose.

Dependability. A strategy I used to enhance dependability was the use of audit trails and data archiving. I maintained clear records of the research steps I used throughout the study as well as my coding schema as a means to help ensure dependability and confirmability. By maintaining these records, another researcher not connected to the study should be able to review my documents to assess whether my findings and conclusions were supported.

Skeptical peer review was another strategy I used to help establish dependability. My peer reviewer, an established methodologist, was able to ask me questions, and address any weaknesses in my understanding, so that I could then learn more and strengthen my knowledge of the use of the appropriate methods to use with my particular mixed methods study.

Another strategy that I employed to help establish dependability was to consistently compare codes to the data to make sure that there was not a change in the meanings of the codes throughout the study. Using a codebook helped me to easily reference codes because I listed all the codes and included an operational definition of each term and gave examples. Utilizing this document throughout my analysis aided me in establishing dependability in my study.

Confirmability. I used multiple strategies to help establish confirmability and stay neutral in my study. My use of triangulation by use of multiple methods and analysts described above to enhance credibility also help to establish confirmability. The use of a skeptical peer reviewer that I described above to establish dependability also helped me to enhance the confirmability of my study and keep it neutral.

Finally, clarifying my bias was essential in the role of the researcher. While I do believe that principals will be able to support their teachers better in science/mathematics instruction if they have attended a mathematics/science-specific professional development, I trust that I was able to keep my own personal feelings in *epoche* and not let them influence my analysis or interpretation. One of the ways that I aimed to do this was by finding disconfirming evidence. I used all the data I found, whether it supported my hypothesis or not. Utilizing all of the strategies described, I was able to establish the confirmability of my study.

Additional threats to validity and reliability. Even though I took steps to enhance the methodological rigor of my study, potential threats to validity and reliability have still existed. Additional possible threats to validity not listed above included selection and maturation (McMillan, 2012). Because principals in the study were selected from different school districts, it is likely that science/mathematics support from district administration varied. One of the three districts in the study had a closer relationship to *Mix it Up* than the other two districts. It is possible that they provided their principals with more information and support regarding principals' roles in effective science/mathematics instruction. Maturation is another possible threat due to participants' own passion for science/mathematics. Participants may have attained information about effective science/mathematics instruction outside of *Mix it Up*. Because participants knew that they would be included in the study, they might also have exaggerated or inflated their scores to come across more accomplished.

Data Sources

For my study, the data sources I used were meant to capture either teachers' perceptions of the roles of principals and their support in science/mathematics instruction or principals' perceptions of themselves in the role of a science/mathematics leader and the support they provide the teachers at their campuses. I utilized surveys and inventories to gather teachers' and principals' perceptions.

I used two sources to obtain teachers' insights on principals as science/mathematics leaders in general as well as their perceptions of the specific support provided by their principals. I used the Principal's Role Survey to capture teachers' perceptions of science/mathematics leaders in general. The Teacher's Perceptions of Principals' Practices that I used, however, measured perceptions of specific principal support in science/mathematics instruction.

The Principals' Perception Inventory was designed specifically to capture principals' perceptions. Part I of the inventory examined principals' perceptions of the support they were providing their teachers in science/mathematics and Parts II and III were designed to gauge principals' perceptions of themselves as science/mathematics leaders in general.

Instrumentation

For my study, the data collection instruments I used were meant to help me examine teachers' and principals' perceptions of principals' support in science/mathematics instruction. In order to obtain information from participants, I designed two instruments to explore teachers' and principals' perceptions of what constitutes the role of science/mathematics leaders. I also created instruments to gauge teachers' and principals' perceptions of science/mathematics support provided by principals.

Principal's Perception Inventory. Before beginning data collection, we first created an instrument titled the Principal's Perception Inventory (see Appendix A). This instrument was designed to examine how principals perceived themselves as science/mathematics leaders as well as the practices principals had implemented to support teachers at their campuses in science/mathematics instruction. This instrument addressed the third research question (3) How did principals perceive themselves in the role of a science/mathematics principal leader? and the fourth research question (4) What were principals' perceptions of their support of teachers in science/mathematics instruction?. Because so little research had been published regarding principals attending science/mathematics professional development and the instruments used to capture perceptions of the principal by both principals and teachers, I created this instrument with a *Mix it Up* program director and another vested researcher conducting research with *Mix it Up* participants.

The questions we chose for part one of this survey were based on current literature regarding best practices in science/mathematics instruction. We started with a priori constructs, which are the characteristics that the instrument is proposed to be assessing. We pulled these science/mathematics best practices from the articles referenced in my literature review as well as the Empower and Constrain chart (see Appendix B) created by *Mix it Up* over years of working with principals in the program. This chart was updated as participants provided more information about principal practices that could either impede or enhance science/mathematics instruction in classrooms.

The chart was initially created in response to open-ended questions given to participants that asked teachers what they needed from principals to support them in science/mathematics instruction and asked principals how better science/mathematics instruction could occur from principal support. These responses were organized into a chart and refined over several years with input from a number of sources including administrators and teachers in the program, participants from conference sessions, classroom observations, and conversations during trainings. One of the *Mix it Up* creators, a vested researcher, and myself then used the items from the chart to create questions for part one of the survey that asked principals about the frequency that they used these particular best practices.

Part one questions were in the form of Likert-scale responses with a place for participants to elaborate on their experiences using open-ended responses. The items reflected strategies that *Mix it Up* had identified as best practices in enhancing science/mathematics instruction. For part two of the survey, we presented principals with vignettes and asked how they might respond to each situation. The two vignettes reflected situations that a science/mathematics principal might be placed in with teachers or parents. In the first vignette, I asked principals to respond to a hypothetical situation in which a teacher is asking for additional space for their science/mathematics instruction, when all spaces have already been assigned. The other vignette imagined a parent approaching the principal to inquire about science labs for their child when there aren't enough materials to implement labs. Finally, for part three, we asked respondents to describe themselves as a science/mathematics leader on their campus. Participants responded to a question asking them who they were as STEM leader on their campus.

To address content validity, I sent this instrument to principals and other experts in the field that were familiar with the purpose of the instrument for expert validation. They examined the items and commented on the appropriateness and clarity of each item. I incorporated their feedback and suggestions into the final version of the instrument.

Teachers Perceptions of Principals' Practices inventory. A program director, a retired principal, and myself then designed an instrument similar to the Principal's Perception Inventory to capture teachers' perceptions of the actions their principals have implemented that support science/mathematics instruction at their campuses. This instrument helped me to answer the second research question, (2) How did principals perceive themselves in the role of a science/mathematics principal leader?. We utilized the Empower and Constrain chart as well as the validated Principal's Perception Inventory to create this survey, called the Teachers' Perceptions of Principals' Practices inventory (see Appendix C).

In the Teachers' Perceptions of Principals' Practices inventory, I included Likert-scale responses and also asked participants to provide additional, relevant information in order to elaborate on their answer choices. We decided to divide the inventory into two sections. The first section addressed the frequency with which principals provided specific supports. The second section focused on the level of support that the principal-provided practices were perceived to have enhanced the teachers' science/mathematics instruction. We made questions in the form of Likert-scale items and also asked participants to elaborate on their experiences using open-ended responses.

Principal's Role Survey. Another instrument called the Principal's Role Survey (Appendix D) I designed was to gauge teachers' perceptions of an effective science/mathematics principal leader. With this instrument, I was able to answer the first research question, (1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?. With this researcher-created survey, I asked participants two open-ended questions about their perceptions of quality science/mathematics leaders. The questions were (1) What do you feel are practices, attitudes, or behaviors that are essential in order for a principal to ensure effective STEM instruction on their campus? and (2) What is the principal's role as a leader in effective STEM instruction?.

Procedures

When I first began my study regarding science/mathematics principals attending professional development with their teachers, I first conducted a literature search to determine what the current literature had to say about the subject. Very few studies have been conducted regarding principals attending professional development themselves. However, none of the studies I found in my search explored both teachers' and principals' perceptions of the role of science/mathematics leaders and the support that they provide teachers at their campus. I was particularly interested in the perceptions of teachers and principals who had experienced a science/mathematics-specific professional development program and had built their own understanding of what constitutes effective science/mathematics instruction and the support needed to provide effective science/mathematics instruction.

I decided to use constructivist (Vygotsky, 1978) and constructionist (Papert, 1991) theories to frame my study because these theories state that through reflection of these experiences and observations, learners construct their own understandings. Constructivist and constructionist views fit closely with my personal views on how teachers and principals understand what *best practices* are for enhancing science/mathematics instruction in the classroom, by experiencing it themselves.

I then met with a program director of *Mix it Up* and other vested researchers to design instruments to gauge teacher and principal participants' perceptions of an effective science/mathematics leader and the support that they provide teachers in science/mathematics instruction. We used available literature and *Mix it Up* documents to design the instruments because instruments were not available in the literature that I could use to address the perceptions of teachers and principals. We designed the Principal's Perception Inventory, then the Teachers Perceptions of Principals' Practices, and finally the Principal's Role Survey.

To gather principals' perceptions about their roles as science/mathematics leaders and the support that they provide the teachers at their campus to support science/mathematics instruction, I asked principals to respond to the Principal's Perception Inventory. Two weeks before *Mix it Up*'s principal summer training in June of 2016, I sent principal participants an electronic version of the Principal's Perception Inventory via email. I asked all principals to complete the inventory before coming to the training. Some returned the inventory electronically while others gave me a printed copy when they arrived at the training. The principal with non-attendance from the prior year did not attend the summer training and did not complete an inventory.

To collect teachers' perceptions of the support that their principal provides to enhance their science/mathematics instruction, I asked teachers to respond to the Teachers Perceptions of Principals' Practices inventory. Teachers completed this inventory during the summer *Mix it Up* teacher training in July of 2016. Participants completed a paper version of this inventory.

To get teachers' perceptions of the role of an effective science/mathematics principal, I asked teacher participants to respond to the Principal's Role Survey. In March of 2017, during an on-site learning visit that was held as part of the *Mix it Up* professional development program, teachers completed the survey. All teachers attending answered the questions on a paper version of the survey anonymously. A timeline of the instruments that I administered to participants is included in Figure 2.

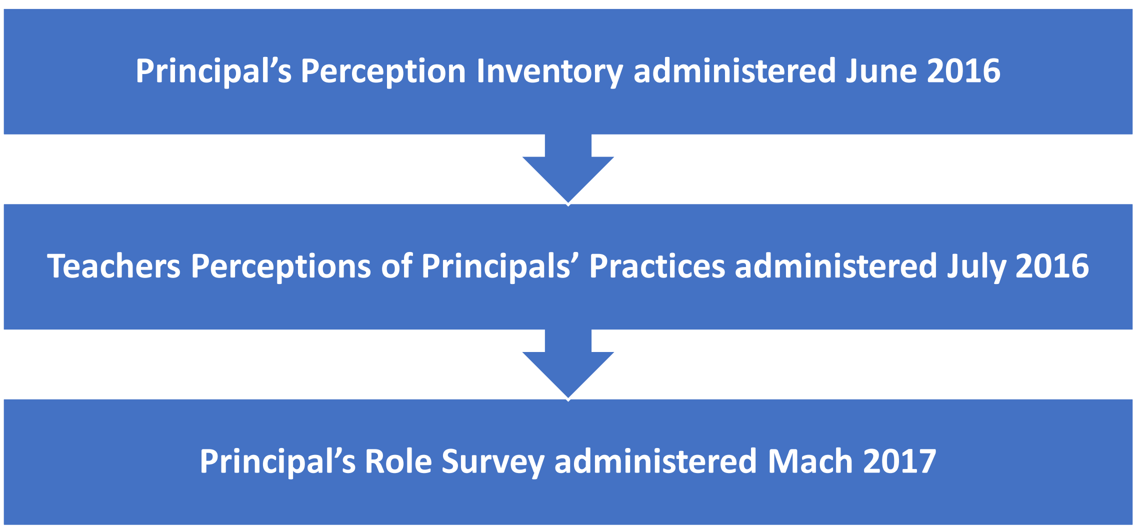

Figure 2. Instrument implementation timeline.

I then utilized attendance records to sort participants into categories based on the number of days they attended *Mix it Up* training before participating in my study. These categories included non-attendance (zero days attended over the school year prior to participating), low attendance (one or two days attended), medium attendance (three to five days attended), and high attendance (more than five days attended). Grouping the participants in that way helped to make differences in responses more apparent in the results (see Table 4 below).

Table 4

Attendance Categories with Number of Days Principals Attended

Category	**Number of Days Attended**[a]	**Principal Participants**
Non-Attendance	0	Seth Gibson
Low Attendance	1-2	Penelope Fitzgerald Sarah Stratton Terence Richards
Medium Attendance	3-5	Milton Myers
High Attendance	5+	Brenda Alvarez

[a]Includes the number of *Mix it Up* training days attended prior to participating in my study

Finally, I analyzed both the quantitative and qualitative data I took throughout the study. I decided to use descriptive statistics to analyze the quantitative portion of my data to show the results in a simple, straight-forward manner. For the qualitative portion of my data, I used Moustakas' (1994) structured approach to qualitative data analysis. Both methods of data analyses are detailed below.

Data Analyses

Because of a mixed methods approach, I used both qualitative and quantitative data analysis procedures. For my qualitative methods, I used Moustakas' (1994) structured approach to data analysis which included coding and identifying patterns and themes in the data and writing a composite description of participants' perceptions. I completed quantitative analysis using descriptive statistics.

Qualitative Data Analyses

In order to analyze the qualitative data I gathered from the Principal's Role Survey, the Teachers Perceptions of Principals' Practices inventory, and the Principal's Perception Inventory, I used Moustakas' (1994) structured method of analysis, which follows specific steps outlined below. Moustakas' steps that I used to complete qualitative data analysis included (1) develop a list of significant statements, (2) group significant statements into broader themes, (3) create a description of *what* the participants experienced, (4) create a description of *how* the experience happened, (5) write a composite description that includes both textural and structural descriptions and gives the essence of the experience.

To follow the steps of Moustakas' (1994) structured method of analysis, I utilized a coding scheme to look for patterns. I analyzed the coded data to determine overarching themes. I then create a codebook to include these themes. Within the codebook, I identified an operational definition of each term, set domain boundaries, and gave examples. Finally, I recorded a tally of the frequency of each response to look for patterns within the data. I also took field notes throughout data analysis. I determined many of the overarching themes through notation.

After reanalyzing the data and field notes taken throughout analysis, I then created a composite description using Moustakas' (1994) structured method of analysis. This narrative described how participants perceived science/mathematics principals as well as what the participants experienced as far as the principal-provided support that occurred while attending the *Mix it Up* program. I used both textural and structural descriptions in my composite description, which was meant to capture the experience of the participants in the *Mix it Up* program in regards to how participants perceived science/mathematics principals and the support that principals provided while attending the program.

Following Moustakas' (1994) structured method of analysis, I used both teacher and principal participants' open-ended responses to describe their impressions of a science/mathematics principal leader. These responses helped me to address my first research question (1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader? and my third research question (3) How did principals perceive themselves in the role of a science/mathematics principal leader?. I also used Moustakas' structured method of analysis to describe participants' perceptions of the support the principals provided to enhance science/mathematics instruction which helped me to answer the second research question, (2) What were teachers' perceptions of the science/mathematics support provided by their principal? and the fourth research question, (4) What were principals' perceptions of their support of teachers in science/mathematics instruction?

Quantitative Data Analysis

Utilizing descriptive statistics, I analyzed the numerical data of the quantitative portion of this study and displayed it using Excel. I initially kept the data from each category of participants (i.e., non-attendance, low attendance, medium attendance, and high attendance) separate and studied the patterns within each. Then I compared data across the different categories to identify similarities and differences. I measured the frequency of specific responses and organized the frequencies into a frequency polygon.

The shape of the graph helps to see how the responses on certain items compare to one another (McMillan, 2012).

By tallying the frequency of responses of different items, I was able to calculate relevant percentages of responses for specific items. The quantitative results provided by the Likert-scale responses from the Teachers Perceptions of Principals' Practices inventory and the Principal's Perception Inventory assisted me in confirming the results to the research questions regarding teachers' and principals' perceptions of the support that principals provided the teachers at their campus to enhance science/mathematics instruction.

The results from the analyses of the quantitative portion of my instruments helped me to support and confirm the results found during qualitative analyses. I also used these results when answering my research questions regarding teachers' and principals' perceptions of support provided by the principal in science/mathematics. Collecting qualitative and quantitative data simultaneously allowed me to validate and expand on the results as well as enhance the credibility of my study.

IV. RESULTS

I organized the findings of my study by research question. Because of the mixed methods approach, I analyzed both qualitative and quantitative data sources for each research question. I used descriptive statistics to analyze the quantitative data and Moustakas' (1994) structured method of analysis to examine the qualitative data.

Teachers' Perceptions

I used two different data sources to gather information from teacher participants in order to answer the research questions relating to teachers' perceptions. To address the first research question, (1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?, I utilized an instrument called the Principal's Role Survey (Appendix D). In order to explore the second research question, (2) What were teachers' perceptions of the science/mathematics support provided by their principal?, I used the Teacher's Perceptions of Principals' Practices inventory (Appendix C).

Teachers' Perceptions of Science/Mathematics Principals

In order to gather teacher participants' perceptions of science/mathematics principal leaders while attending the *Mix it Up* science/mathematics training, I gave participants an open-ended survey, called the Principal's Role Survey (Appendix D) to complete. Questions I included were (1) What do you feel are practices, attitudes, or behaviors that are essential in order for a principal to ensure effective STEM instruction on their campus? and (2) What is the principal's role as a leader in effective STEM instruction? I sorted the coded responses to this survey into overarching themes. The results, organized into themes, are listed in Table 5.

Table 5

Frequency of Teachers' Responses Regarding Perceptions of Effective Science/Mathematics Principals

Principals providing resources
• Provides needed materials and equipment (7)
• Allocates funds needed for STEM instruction (4)
Principals' and teachers' knowledge
• Provides/encourages professional development (7)
• Knowledge of science/mathematics best practices (7)
Principals' communication
• Present in trainings, meetings, etc. (3)
• Allows for/encourages collaboration and alignment (3)
• Open communication and feedback (3)
• Monitors teacher growth (3)
• Communicates clear expectations (1)
• Models lessons (1)
Principals' protection of teachers' time
• Ensures sufficient planning time (3)
• Protects instructional time (2)
Principals providing a supportive STEM ethos/culture
• Open-minded/embraces new STEM advances (5)
• Defends STEM culture (2)
• Supports the use of technology (1)

The themes that participants reported as being important in the role of science/mathematics principals included *principals providing resources, principals' communication*, *protection of teachers' principals' protection of teachers' time*, *principals' and teachers' knowledge*, and *principals providing a supportive STEM ethos/culture*.

Principals providing resources. Of the thirteen teacher participants, 69% of them responded that providing appropriate resources was an important aspect of the role of an effective science/mathematics principal. Resources specified by participants included both materials and equipment. Participants' responses involving funding were also coded under this category when the funding pertained to materials and equipment. For example, one participant stated that one of the responsibilities of a leader in effective STEM instruction was to, "find, fund, [and] produce resources to support [the] classroom".

Principals' and teachers' knowledge. Both content-specific knowledge as well as content-specific pedagogical knowledge were characteristics that teacher participants listed as being essential in an effective science/mathematics principal. Eighty-six percent of the teacher participants included responses that were coded in the *principals' and teachers' knowledge* category. Coded statements included in this category contained both knowledge held by the principals themselves as well as the role of aiding teachers in attaining the knowledge that they need through professional development. Examples of participant responses included the importance of "professional development that is specific to subjects being taught", principal's "knowledge of STEM", and "knowledge of best practices".

Principals' communication. Many of the participants also responded that communication was an important characteristic in an effective science/mathematics principal. Sixty two percent of participants' responses included statements about communication. Participants were more detailed and specific in this category than any other category. Some statements cited principal presence in trainings and meetings such as, "I feel a principal should be involved in the training or professional development". Other responses referred to open and timely communication after observations. For example, one participant stated that there needed to be "conversation about why you taught it that way", when referring to classroom observations.

Still others reported that communication through collaboration with teams and other teachers to better align instruction was important to them and that a principal should encourage and support these collaborations. One teacher specified that principals should "make sure teachers are able to work [and] collaborate [with] each other". Still others stated clear expectations were important in an effective science/mathematics principal. Participants included statements about principals providing ideas and modeling lessons, monitoring teacher growth, and developing an assessment tool so teachers know what the principal expects in a science or mathematics lesson.

Principals' protection of teachers' time. Time is another issue that participants cited as something that principals should protect. Thirty one percent of teacher participants responded with statements about time. Both protection of instructional time as well time to plan and collaborate were mentioned by participants. One participant wrote that an effective science/mathematics principal should have an "acceptability of time requirements" associated with teaching mathematics and science. Another participant felt the role of a science/mathematics principal was to allocate time for meetings and planning in addition to the regular planning period that teachers receive.

Principals providing a supportive STEM ethos/culture. Finally, a common theme found among participants in regards to effective science/mathematics leaders was that the principal have an open mind to new STEM advances and not only embrace, but defend a STEM culture on their campus. Thirty eight percent of teacher participants made statements regarding maintaining a supportive STEM ethos or culture as an important aspect of a science/mathematics principal. For some participants, a principal that was supportive of STEM would be “open to new knowledge [and] practices” and “willing to try new advances in both tech [and] education”. Other participants stated that it was important to advocate STEM learning throughout the community and defend the use of STEM on campus to upper administration.

Discussion of teachers’ perceptions of science/mathematics principals. Teacher participants helped me to answer research question (1) What were teachers’ perceptions of what constitutes the role of an effective science/mathematics principal leader? by completing the Principals’ Role Survey. Overall, teachers felt that in order to be an effective science/mathematics leader, a principal should provide necessary materials and equipment, have open communication and provide feedback, have science/mathematics-specific knowledge and help their teachers to attain the same, protect teachers’ instructional and planning time, and have a supportive STEM culture on their campus. These findings were not surprising when compared to the STEM Principals Empower and Constrain chart (Appendix B) that the *Mix it Up* program directors developed based on research and experience over time. Many of the same topics were addressed on their chart, including principals' knowledge, providing resources, protecting teachers' time, and open communication and collaboration. The only theme from my research that was not present on the Empower and Constrain chart was having a supportive STEM culture. Although this principle is inherent throughout the *Mix it Up* chart, a supportive STEM ethos or culture is not clearly stated as a practice. Generally, teacher participants' perceptions of effective science/mathematics principals seemed to match closely to the expectations that the *Mix it Up* program has designed for their principals and have deemed to be best practices in supporting science/mathematics instruction.

Teachers' Perceptions of Principal-Provided Science/Mathematics Support

I then collected information from teacher participants regarding the actions that they perceived their own principals implementing to support science/mathematics instruction in order to answer research question (2) What were teachers' perceptions of the science/mathematics support provided by their principal?. I utilized the Teacher's Perceptions of Principals' Practices inventory to gather teachers' perceptions of their principals' support. The majority of the data I collected from this instrument were quantitative, as it contained predominately Likert-scale responses. However, I also asked participants to provide any additional information they felt was relevant in an open-ended format at the end of the survey.

I organized the data I collected from the Teacher's Perceptions of Principals' Practices first into the four principal attendance categories. I then analyzed the results within and among categories. Attendance categories included *non-attendance*, which means that the principal attended zero of the *Mix it Up* training days offered over the school year prior to taking the inventory. The *low attendance* category means that the principal attended one or two days of the training days offered. *Medium attendance* indicates that three to five days were attended, and *high attendance* means that the principal attended more than five training days over the prior school year. I organized the results of the *professional support* and *instructional support* sections of the Teacher's Perceptions of Principals' Practices into frequency polygons to show how the results differ among the different principal attendance categories.

Principal-provided professional supports. Figure 3 below is the frequency polygon that represents participants' overall responses to the *professional support* section of the survey. As the graph indicates, a majority of responses from the teacher participant that had a principal with non-attendance indicated that the principal was providing the identified professional supports specified on the survey *rarely*. Teacher participants with a principal with low attendance indicated in a majority of their responses that their principals provided the identified professional supports *sometimes*. Principals with medium attendance had teachers that responded that their principal provided these identified supports *always* and the participant with a high attending principal indicated that their principal provided the identified professional supports *often*.

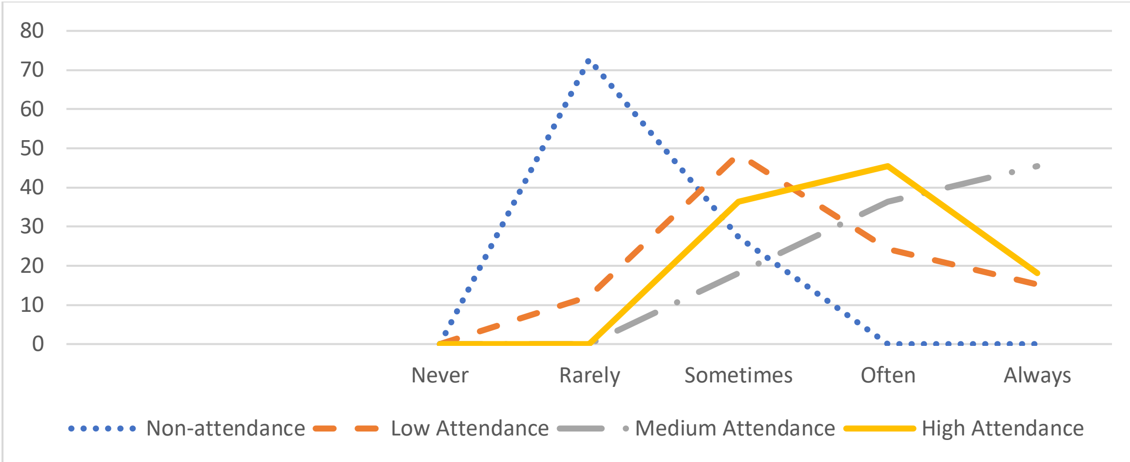

Figure 3. Frequency polygon for teachers' perceptions of principal-provided professional support.

Four of the identified principal-provided supports on the Teacher's Perceptions of Principals' Practices (Appendix C) matched closely with themes that I identified when analyzing teacher participants' perceptions of an effective science/mathematics principal from the Principal's Role Survey. One of the themes I previously identified was *principals' communication*, which included conducting observations and providing feedback. This theme matched closely to item number four on the Teacher's Perceptions of Principals' Practices inventory which addressed the frequency of observations and feedback provided by principals. *Principals' protection of teachers' time*, including the protection of planning time, was another theme I identified. This theme matched well with item number nine on the inventory that focused on the amount of time that principals ensured for collaborative planning time for teachers.

Principals' and teachers' knowledge, including providing professional development, was another theme I identified. Item number ten on the inventory related well with theme of knowledge as it specified the frequency with which principals assured focused professional development, based upon best practices, occurred for teachers.

Finally, the identified theme of *principals providing resources* related closely to item eleven on the inventory. This item discussed the regularity with which principals assured materials, resources and supplies specific to teaching assignment were provided.

The Likert-scale items on the Teacher's Perceptions of Principals' Practices (Appendix C) that most closely corresponded with the themes found included statements about the frequency with which the principal conducted observations and provided feedback, protected collaborative planning time, ensured quality professional development, and ensured resources are provided. I included graphs for comparison in Figure 4 that show the responses of teachers in reply to the four specific inventory items on the survey. With the graphs, one can see that out of the four different attendance categories, the principal with non-attendance is the only to be perceived to be providing the identified supports *rarely* in response to all four items. All other principals were perceived to provide the supports *sometimes*, *often*, or *always*. None of the principals were perceived to *never* be providing the supports.

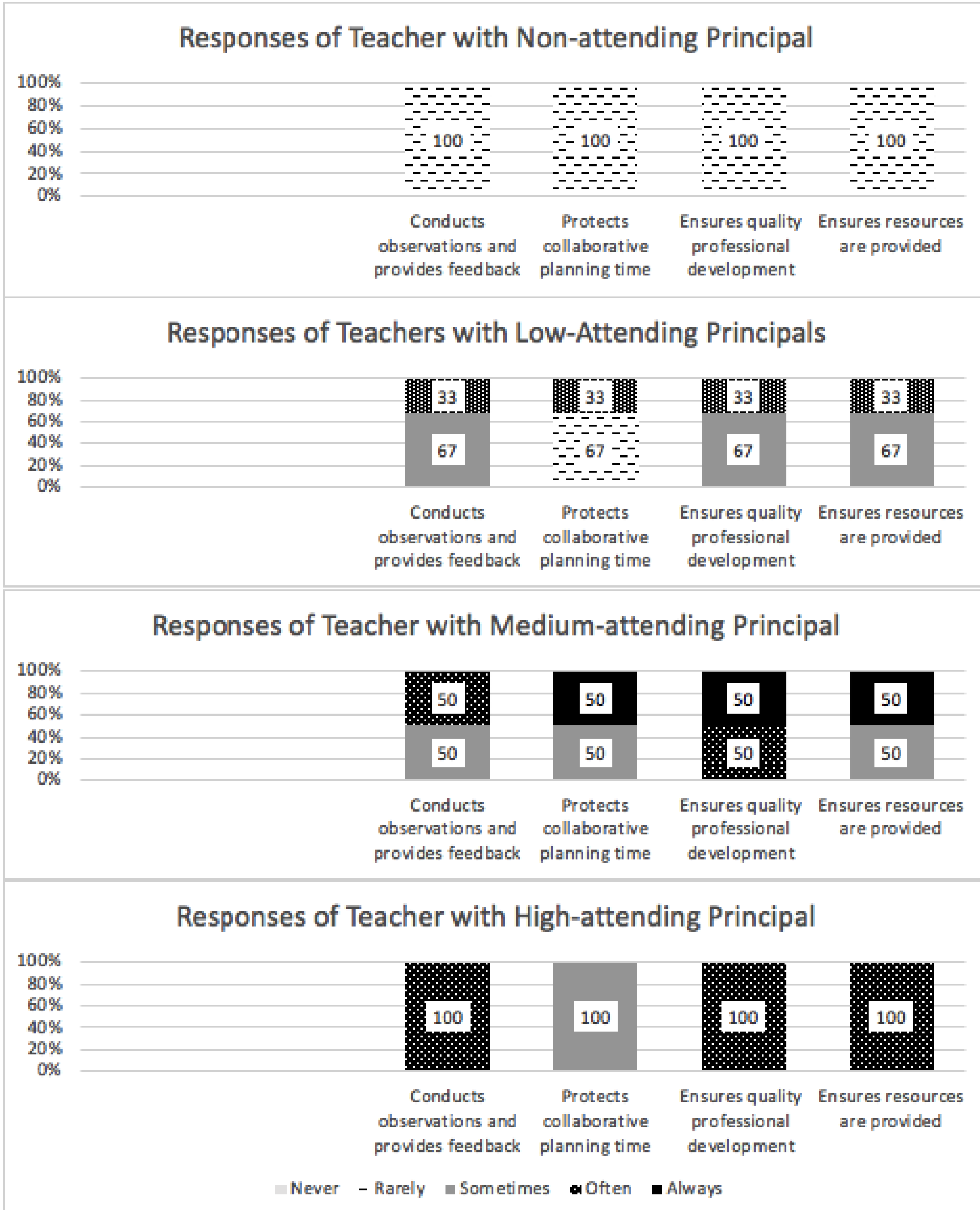

Figure 4. Comparison graphs showing teachers' responses regarding the amount of *professional supports* provided by principals.

Principal-provided instructional supports. Figure 5 below is the frequency polygon that displays participants' overall responses to the *instructional support* section of the survey. As the graph indicates, teachers' perceptions were that the principal with non-attendance did not support instruction with their instructional practices as much as principals that had attended the *Mix it Up* training. The results were similar to those of the *professional support* section of the survey.

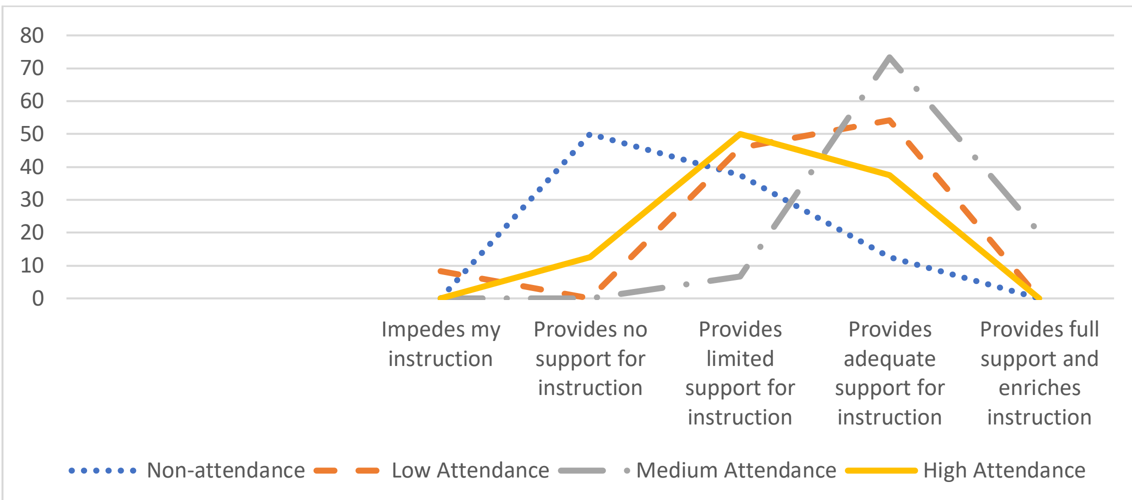

Figure 5. Frequency polygon for teachers' perceptions of principal-provided instructional support.

I then examined the four items from the *instructional support* section of the survey that most closely related to the themes I discovered from the Principal's Role Survey (Appendix D). The themes I identified from the survey were *principals providing resources* and *principals' and teachers' knowledge*, including best practices in science/mathematics, as well as *principals' protection of teachers' time*, including the protection of instructional time.

Item number twelve on the Teacher's Perceptions of Principals' Practices inventory connected to the theme of *principals providing resources*. Item twelve addressed the level of support that the principal-supplied resources provide the teacher.

Two items on the survey related to the theme of *principals' and teachers' knowledge*. Items fifteen and sixteen on the inventory addressed the level of principals' knowledge of best practices in both science and mathematics and how that knowledge influenced teachers' instruction. Finally, the theme of *principals' protection of teachers' time* matched well with item number eighteen on the inventory that focused on the principal's use of instructional time. I created comparison graphs to see the differences in responses to the four related items among the principal attendance categories. The results are shown in Figure 6.

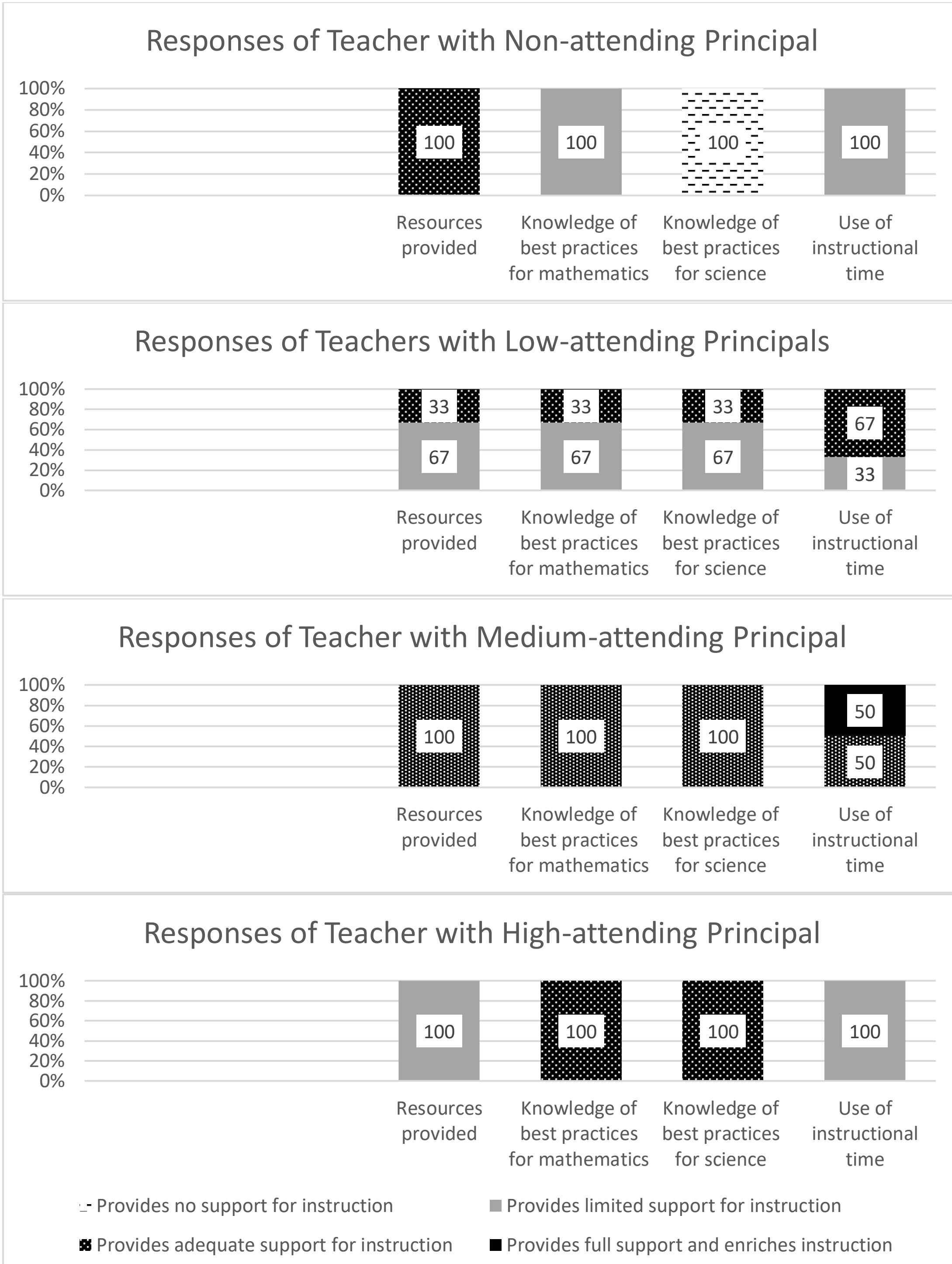

Figure 6. Comparison graphs showing teachers' responses regarding the level of support of *instructional supports* provided by principals.

When comparing among graphs, I found that participants with principals that had little or no attendance in the program reported that the principal-provided practices identified in these four inventory items provided mostly *no* or *limited support* for teachers' instruction. Whereas, participants with teachers who had medium or high attendance reported that a majority of the principal-provided practices identified in these inventory items provided *adequate support* for their instruction, with the exception of one participant reporting *limited support* on two items and another participant reporting *full support* on one item.

Open-ended responses. In the optional, open-ended portion of the inventory, I asked participants to share any additional information they considered helpful. Four of the seven teacher participants chose to include responses to the open-ended portion of the survey. Their statements were similar to the responses from the Principal's Role Survey. Two participants with low attending principals commented on the need for protected planning time to collaborate with other teachers and plan lessons. One stated that because of all the responsibilities of a teacher during their normal planning time that "planning time is having to happen after hours". These remarks related to the theme of time that I found when analyzing the results of the Principal's Role Survey.

A participant with a non-attending principal stated that "detailed feedback is needed" as well as following up on discussions of goals, instructional ideas, etc. This participant's comments fit well with the theme of *principals' communication* I identified earlier. Finally, a participant with a principal that had medium attendance stated that they wanted their principal to trust that their teaching practices were based on best practices for science/mathematics. While this comment related to the identified theme of *principals' and teachers' knowledge*, it also related to teacher autonomy and trust, a theme not identified in previous responses.

Discussion of teachers' perceptions of principal support. In response to research question (2) What were teachers' perceptions of the science/mathematics support provided by their principal?, I found that teacher participants identified qualities and behaviors that matched closely with best practices identified by *Mix it Up* to support science/mathematics instruction. Teachers shared that many of their principals implemented several of these professional and instructional practices and that the practices they implemented generally provided sufficient support.

However, the practices seemed to rarely take place or provide appropriate support if the principal had not attended a science/mathematics-specific training that identified the needed principal-provided professional and instructional supports. Once principals have attended training and understand the needed principal supports, principals seem more likely to actually implement these science/mathematics supports than if they had not attended the training from the perspective of their teachers. Also, the practices implemented by principals seemed to better support teachers' instruction in science/mathematics if they had attended a science/mathematics-specific professional development.

Principals' Perceptions

I utilized two different data sources to collect information from principal participants to answer the research questions relating to principals' perceptions. To address the third research question, (3) How did principals perceive themselves in the role of a science/mathematics principal leader? and the fourth research question (4) What were principals' perceptions of their support of teachers in science/mathematics instruction?, I used the Principal's Perceptions Inventory (Appendix A).

Principals' Perceptions of Science/Mathematics Principals

On part three of the Principal's Perception Inventory, I asked principal participants who they were as a STEM leader on their campus. In part two of the inventory, I asked principal participants to respond to two hypothetical vignettes. I used these questions to gather principal perceptions of themselves as a science/mathematics leader to answer the third research question (3) How did principals perceive themselves in the role of a science/mathematics principal leader? After using Moustakas' (1994) structured method of analysis to code and organize the coded responses to this inventory, I then organized the coded responses into overarching themes. These themes included *principals' communication*, *principals managing budget*, *principals' and teachers' knowledge*, and *principals providing a supportive STEM ethos/culture*. Although the themes were similar to those I found when analyzing teacher perceptions of a science/mathematics principal, there were some notable differences. Participant statements that I organized into themes are listed below in Table 6.

Table 6

Frequency of Principals' Responses Regarding Perceptions of Effective Science/Mathematics Principals

Principals' communication
• Allows for/encourages collaboration among teachers (3)
• Solicits teacher input (3)
• Maintains parent communication (3)
• Monitors teacher growth (3)
• Communicates clear expectations (2)
• Provides modeling (1)
• Present in trainings, meetings, etc. (1)

Principals managing budget
• Petitions community/business partners and grants for aid (4)
• Budgets for materials/equipment (3)
• Seeks aid from parent-teacher organizations (3)
• Manages school budget effectively (3)

Principals' and teachers' knowledge
• Knowledge of science/mathematics best practices (5)
• Provides/encourages professional development (2)
• Knowledge of state science standards (2)
• Life-long learner (2)

Table 6 (continued)

Frequency of Principals' Responses Regarding Perceptions of Effective Science/Mathematics Principals

Principals providing a supportive STEM ethos/culture
• Open-minded/embraces new STEM advances (2)
• Supports the use of technology (1)
• Creates campus-wide STEM projects (1)
• Makes STEM a part of the campus improvement plan (1)

Principals' communication. With 100% of the five principal participants responding that communication was an important aspect of being a science/mathematics principal, I found that communication was a theme in both teacher and principal perceptions of science/mathematics principals. Principals made statements about communication involving encouraging collaboration among teachers, monitoring teacher growth, communicating clear expectations, being present in trainings and meetings, and providing modeling that were all similar to comments made by teacher participants. However, communication was expressed in slightly different ways by principals as well. Principal participants made remarks about soliciting teacher input when they "poll the teachers" or "gather all [their] science teachers together" to solve a problem. Principal participants also made statements about the importance of maintaining parent communication through a newsletter or by hosting a STEM parent night.

Principals managing budget. All of principal participants also responded that considering a budget for STEM was important as a science/mathematics principal. For some, this meant allocating money from the school budget for science/mathematics materials and equipment. For others, it meant soliciting help as needed from local parent-teacher organizations. Every participant mentioned using community and business partners or grants to ensure they have enough in their budget for materials or other science/mathematics needs. Budget seemed to be a particularly important issue for principals. The related theme of *principals providing resources* that I found in teacher perceptions was slightly different than the *principals managing budget* theme I found with principals. While teachers focused mostly on the materials and equipment that they needed to successfully teach science/mathematics and the funds needed to do so, principals focused more on the importance of finding sources of funding to support science/mathematics instruction.

Principals' and teachers' knowledge. With 100% of principal participants reporting that they also found knowledge to be an important aspect of a science/mathematics principal, I found that this theme was present in both teachers' and principals' perceptions. Every single participant, both teachers and principals, commented that a knowledge of science/mathematics-specific best practices was important as a science/mathematics principal. With best practices being at the forefront of every *Mix it Up* training, it was not surprising that participants felt that knowledge of best practices was essential in science/mathematics principals. In addition to principals' knowledge and ensuring appropriate professional development, principal participants also identified a knowledge of state science standards as being an aspect of effective science/mathematics principals. One participant mentioned the need to have all science teachers commit to having at least 40% of instructional time dedicated to labs, which is a state standard. Another participant mentioned the importance of reviewing the state standards before planning science/mathematics instruction.

Principals providing a supportive STEM ethos/culture. Just like teacher participants, many principals also reported that embracing and advocating for a positive STEM culture at their campus was an important characteristic of being science/mathematics principals. Sixty percent of principal participants mentioned embracing new STEM advances or supporting the use of technology, like teacher responses. Principals, however, also mentioned creating campus-wide STEM projects and making STEM a part of their campus improvement plan.

Discussion of principals' perceptions of science/mathematics principals. Principal responses to the Principal's Perception Inventory assisted me in answering the fourth research question (3) How did principals perceive themselves in the role of a science/mathematics principal leader? In general, principal participants expressed that in order to be effective science/mathematics leaders, principals should have open communication and collaboration, be able to budget and find funding to provide necessary materials and equipment, have science/mathematics-specific knowledge and help their teachers to attain the same, and have a supportive STEM culture on their campus. Most of these findings were not surprising as they relate closely to practices identified by *Mix it Up* on their Empower and Constrain chart (Appendix B) as well as teacher participants' responses. However, even though 31% of teacher participants stated that the protection of instructional and planning time was important to them in being effective science/mathematics principals, instructional or planning time was not mentioned by principal participants in their responses. The protection of instructional time is one of the best practices listed on *Mix it Up's* Empower and Constrain chart.

Principals' Perceptions of Principal-Provided Support

I designed part one of the Principal's Perception Inventory to answer the fourth research question (4) What were principals' perceptions of their support of teachers in science/mathematics instruction?. In part one of the inventory, principal participants responded to Likert-scale items that addressed the frequency with which principals implemented the identified best practices. In addition to the Likert-scale responses, participants also elaborated on their answers to each item in a narrative format. Therefore, I analyzed both qualitative and quantitative results and used the qualitative findings to support the quantitative results.

I organized the data collected from the Principal's Perception Inventory by using the principal attendance categories of *low attendance*, *medium attendance*, and *high attendance*, then. Due to non-attendance, I was unable to get one principal to complete an inventory, therefore do not have a category of non-attendance for this section. After analyzing the results within and among categories, I organized the findings of the Principal's Perception Inventory into a frequency polygon to show how the results of participants in different attendance categories compare and contrast.

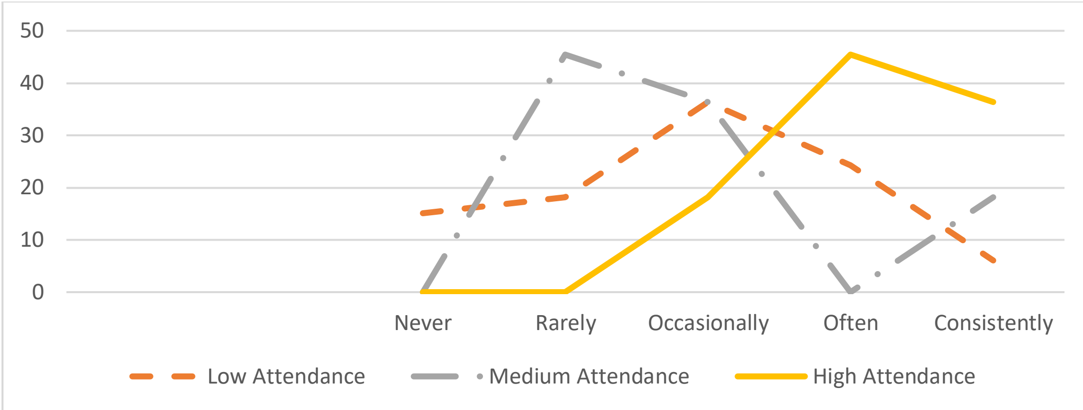

Figure 7. Frequency polygon for principals' perceptions of principal-provided support.

Principal-Provided Supports. Figure 7 is a frequency polygon that shows the overall results of the Principal's Perception Inventory. A majority of the responses of the high-attending principal indicated that they were providing the supports *often* and *consistently*. The principal with medium attendance reported that most of the practices were being provided *rarely*, but reported that some of the practices were being provided *consistently*. The principals with low attendance had a range of responses that indicated that some of the supports were being provided *never*, others *rarely*, many *occasionally*, some *often*, and one *consistently*. I then examined responses to five of the items from part one of the Principal's Perception Inventory because they matched closely to themes I identified earlier about principals' perceptions of science/mathematics principals from parts two and three of the inventory.

Item number six from the inventory discussed the frequency with which principals examined their budgets with STEM teaching and materials in mind. This item matched closely with the theme of *principals managing budget* that principals identified as being an important aspect to consider as a science/mathematics principal. Inventory item number seven described the regularity with which principals advocated for STEM-specific professional development. Item seven related closely to the theme I identified regarding *principals' and teachers' knowledge*, including ensuring quality professional development. Item eight addressed how often principals protected teachers' instructional time, which related to the theme of *principals' protection of teachers' time* identified by teachers' perceptions. Connecting to the theme of *principals' and teachers' knowledge* and best practices, item number ten asked principals about how often they ensured that science/mathematics-specific best practices were taking place on their campus. Finally, item number eleven addressed principals providing the materials and equipment needed for teachers to successfully teach science/mathematics which also related to the identified theme of *principals managing budget*.

Figure 8 contains comparison graphs used to see the differences in principals' responses to the five items chosen from the survey that best matched the identified themes of principal support. The results of the principal with high attendance showed that they perceived that they provided the identified supports to teachers *often* or *consistently* and the low attending principals perceived themselves providing many of the supports *rarely* and *occasionally*. The principal with medium attendance had responses that showed that they perceived that they provided the supports *rarely*, *occasionally*, or *consistently*, which was a larger range in responses than the other participants.

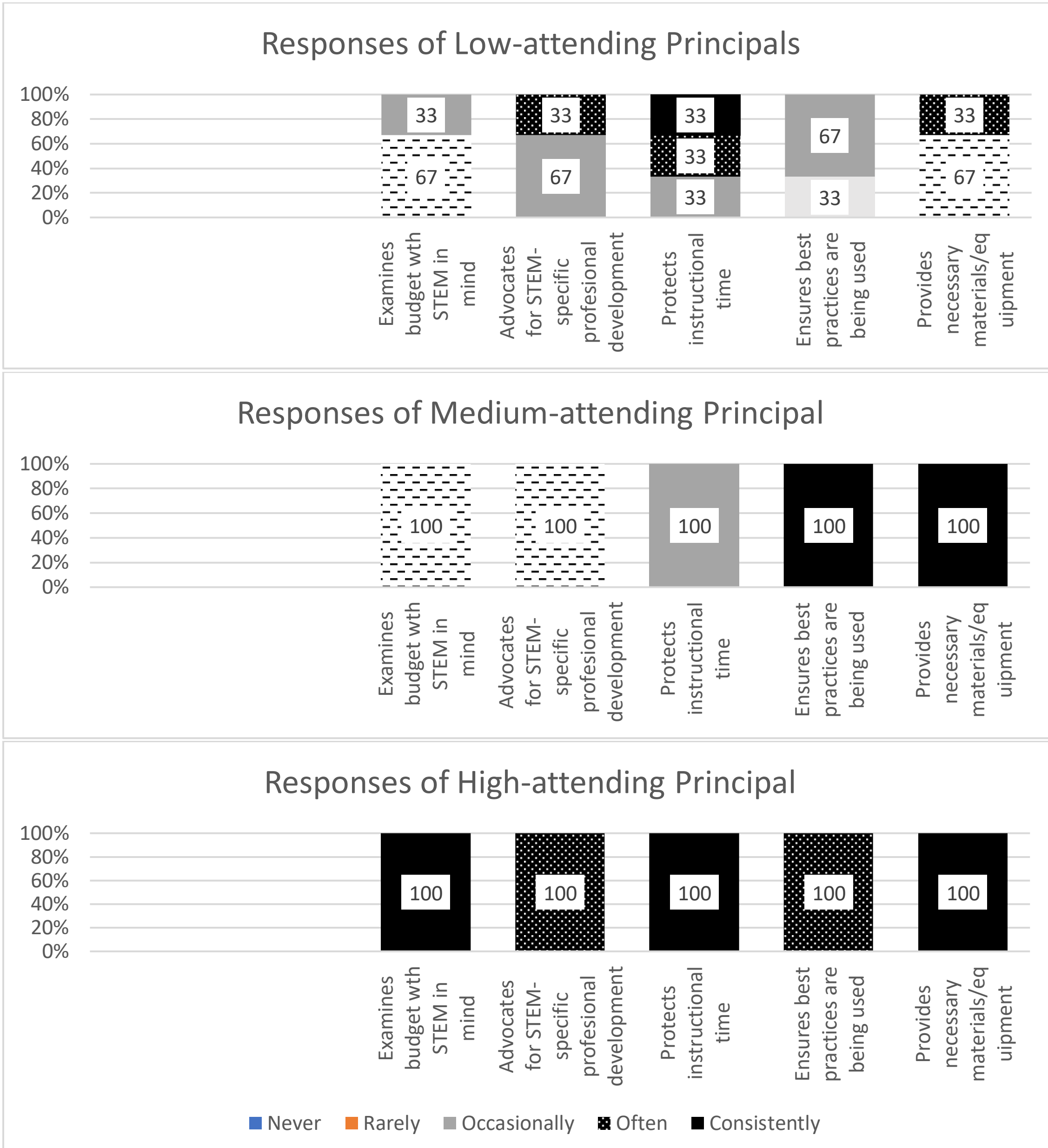

Figure 8. Comparison graphs showing principals' responses regarding principal-provided support.

Open-ended responses. The narrative responses helped me to better understand participants' responses. The principal with high attendance wrote about creating a STEM-specific budget that had not existed before while seeking teacher input in the matter, sending teachers to national conferences for STEM-specific professional development, and conducting observations to monitor teacher growth in teachers' use of science/mathematics best practices. This principal noted additional practices that matched *Mix it Up*-identified supports that were not inherent in the item descriptions by mentioning teacher input and observations.

The medium-attending principal seemed to have a large range of responses on the five identified items from the inventory. This participant described the disparate results by relating the constraints that they felt hindered them from providing the needed supports. They explained limitations such as small budget, lack of central administration support, time constraints due to dedicated periods such as athletics, etc., as well as many teachers being coaches who are often not available before and after school. They mentioned, however, that ensuring the use of best practices on campus was something that they felt confident about. They explained that they provided clear expectations to teachers in regard to the use of best practices in the classroom and had "teachers in like content areas working together to mentor each other, work on lesson plans, assessments, and establishing quality engagement in their teaching expectations". This principal also highlighted additional previously identified supports such as clear expectations as well as teacher collaboration and input.

Two of the three low-attending principals made statements about finding money to use on a small amount of science/mathematics-specific materials and equipment, whereas one mentioned that they had "not examined [their] budget regarding STEM unless honoring a request for [the gifted and talented] teacher to purchase materials". Regarding professional development, two principals wrote that they had sent teachers to

STEM-specific professional development, but another responded that they still had questions for the *Mix it Up* directors regarding appropriate professional development.

Finally, one low-attending participant reported that they made sure that best practices were taking place in their gifted and talented classroom, but had not ensured that best practices were happening in the rest of the classrooms. Another stated that they had never checked to ensure that science/mathematics-specific best practices were taking place at their campus, while another mentioned a book that they had science/mathematics teachers read in order to aid them in science/mathematics best practices. None of the low-attending principals mentioned any of the additional identified supports that the medium and high-attending principals cited.

Discussion of principals' perceptions of principal support. In answer to the fourth research question (4) What were principals' perceptions of their support of teachers in science/mathematics instruction?, I found that principal participants identified behaviors and qualities closely related to characteristics identified by teacher participants as well by *Mix it Up* as best practices to support science/mathematics instruction. While the principal with high attendance seemed to support their teachers most with the behaviors and qualities they reported, low and medium-attending principals also reported that they provided many of the supports at least occasionally.

The themes I analyzed from principal perceptions of the support that a science/mathematics principal provides concurred with the results gained from teacher participants on the same subject. The results suggested that attending science/mathematics-specific professional development enabled principals to better identify and provide the specific science/mathematics support that teachers needed to be successful in implementing effective science/mathematics instruction in their classrooms. It appeared that the more days that principals attended the *Mix it Up* training, the better they were able to identify and provide appropriate science/mathematics support.

V. CONCLUSION AND RECOMMENDATIONS

My study aimed to find teachers' and principals' perceptions of science/mathematics leaders and the support that they provided their teachers when attending a science/mathematics-specific professional development program. Teachers and principals in the program that met the criteria completed surveys and inventories to help me to answer my research questions which are listed below.

(1) What were teachers' perceptions of what constitutes the role of an effective science/mathematics principal leader?

(2) What were teachers' perceptions of the science/mathematics support provided by their principal?

(3) How did principals perceive themselves in the role of a science/mathematics principal leader?

(4) What were principals' perceptions of their support of teachers in science/mathematics instruction?

Summary of Results of Mixed-Method Design

I utilized a mixed methods approach in my research design, collecting both qualitative and quantitative data from participants. I used descriptive statistics and Excel to analyze and display the quantitative portion of my study. Moustakas' (1994) phenomenological approach was the guide that I used to analyze and describe my qualitative data.

Perceptions of the Role of Science/Mathematics Leaders

In response to the first two research questions regarding teachers' and principals' perceptions of the role of science/mathematics leaders, I found that teachers and principals identified common qualities and behaviors in science/mathematics principals that can support teachers' science/mathematics instruction. The common themes were *principals' communication*, *principals' and teachers' knowledge*, and *principals providing a supportive STEM ethos/culture*. The common themes that I found are displayed below in Table 7. I also discussed the other two themes found in my study. *Principals protection of teachers' time* was found in teachers' responses, but not principals' responses. The themes of *principals providing resources* and *principals managing budget* were found in teachers' responses and principals' responses, respectively.

Table 7

Common Themes Between Teachers' and Principals' Perceptions of Effective Science/Mathematics Principals

Theme	Described by teachers	Described by principals
Principals' communication	• Present in trainings, meetings, etc. • Allows for/encourages collaboration and alignment • Monitors teacher growth • Communicates clear expectations • Models lessons • Open communication and feedback	• Present in trainings, meetings, etc. • Allows for/encourages collaboration among teachers • Monitors teacher growth • Communicates clear expectations • Provides modeling • Solicits teacher input • Maintains parent communication
Principals' and teachers' knowledge	• Provides/encourages professional development • Knowledge of science/mathematics best practices	• Provides/encourages professional development • Knowledge of science/mathematics best practices • Knowledge of state science standards • Life-long learner
Principals providing a supportive STEM ethos/culture	• Open-minded/embraces new STEM advances • Supports the use of technology • Defends STEM culture	• Open-minded/embraces new STEM advances • Supports the use of technology • Creates campus-wide STEM projects • Makes STEM a part of the campus improvement plan
Principals providing resources/ Principals managing budget	• Provides needed materials and equipment • Allocates funds needed for STEM instruction	• Budgets for materials/equipment • Manages school budget effectively • Petitions community/business partners and grants for aid • Seeks aid from parent-teacher organizations
Principals' protection of teachers' time	• Ensures sufficient planning time • Protects instructional time	*Not cited by principal participants

The theme of *principals' communication* reported by participants involved principals' presence in trainings and meetings, open and timely communication after observations, teacher collaboration, and clear expectations from principals. *Principals' and teachers' knowledge* mainly included knowledge held by principals themselves as well as the role of aiding teachers in attaining the knowledge that they need through professional development. The theme of *principals' supporting a STEM ethos/culture* contained statements about principals embracing STEM and new STEM-related advances as well as advocating for and defending STEM education on their campus. The theme of *principals managing budget* found in principal perceptions closely matched the theme of *principals providing resources* found in teacher perceptions.

The most notable difference between the two was that teachers reported a need for principals to provide appropriate resources, whereas principals reported that the funding of these resources from the school budget and other resources was the bigger issue that they considered. Finally, the theme of *principals' protection of teachers' time* that was found in teacher perceptions was not present in principal perceptions. Teachers felt that principals needed to be able to protect their instructional and planning time, however, none of the principal participants mentioned time as a needed consideration for science/mathematics leaders.

Perceptions of Principal-Provided Support

In answer to the second research question about the level of support that principals provided their teachers to support science/mathematics instruction, both teacher and principal participants reported that principals were generally providing the necessary supports to some extent, especially the principals that had attended at least some professional development training. In providing the supports, there appeared to be a large difference in principal-provided supports perceived by teacher participants depending on whether their principal had attended even one day of training or not. It appeared that the principals that attended at least one day of training provided a greater number of science/mathematics supports than the principal that did not attend. However, after attending at least one day, the number of days principals attended did not seem to influence greatly the amount of identified professional and instructional supports that principals provided.

However, when speaking to the level of support that the professional and instructional practices actually provided the teachers at their campus, additional principal attendance in the training may have helped principals to have a better understanding of how these practices influence teachers. With that knowledge, principals seemed to be able to provide a higher level of support to teachers in science/mathematics instruction than principals that had attended little or no science/mathematics-specific professional development.

Alignment with *Mix it Up*-Identified Best Practices

The characteristics and qualities identified by teacher and principal participants related closely to the practices identified by *Mix it Up* to enhance science/mathematics instruction. The Empower and Constrain chart (Appendix B) listed behaviors and qualities that *Mix it Up* identified as best practices to support science/mathematics. The chart included many of the same characteristics that participants named in responding to my surveys and inventories.

It was not surprising to me that principals that attended even one day of the *Mix it Up* professional development program seemed to understand better the best practices needed to support teachers and enhance science/mathematics instruction at their campuses. *Mix it Up* program directors made sure to disseminate this information clearly and provide handouts for later reference. The program directors also modeled the best practices themselves as they guided participants through understanding what effective science/mathematics instruction looks like and feels like. Having participants experience the learning themselves allowed them to build a deeper understanding of the different aspects of effective science/mathematics instruction.

Related to Theoretical Framework

My original proposition was that, with a constructivist (Vygotsky, 1978) and constructionist (Papert, 1991) approach, principals' experiences gained through participation in quality professional development with teachers from their campuses would lead to principals being more aware of effective principal-provided science/mathematics support. Furthermore, I stated that the knowledge gained through attending a quality professional development would better equip principals to provide more effective support in their teachers' efforts to utilize science/mathematics best practices and improve science/mathematics instruction and learning on their campuses.

In accord with constructivist (Vygotsky, 1978) and constructionist (Papert, 1991) theories, I believe that participants must have positive experiences with effective mathematics/science teaching strategies themselves as they learned mathematics/science. Through reflection of these experiences and observations, learners are able to construct their own understandings. Therefore, I continue to believe that in order for principals to more fully understand what constitutes effective science or mathematics instruction, principals should experience first-hand, quality science/mathematics teaching and learning themselves.

Related to Current Literature

Current literature is available that individually examines the effectiveness of science/mathematics professional development programs. Separate studies are available that explore best practices in teaching science/mathematics. Still other studies currently available in the literature focus on the role of principals in supporting teachers in instruction.

However, there is not any literature available that gathers perceptions of how principals attending a science/mathematics-specific professional development program with the teachers on their campuses could influence the level of support that principals provide teachers in enhancing science/mathematics instruction in the classroom. My study is specific in that it examined both perspectives, the principals' and the teachers', regarding the role of science/mathematics principals and the support that they provided teachers at their campuses. The phenomenon of the science/mathematics principal attending a science/mathematics professional development program with teachers had yet to be explored and described. My study helped to fill this gap in the available literature as well as warrant future studies on the subject.

Limitations of My Study

Lack of time and resources caused some limitations in my study. Small sample size and not being able to replicate the study were the main limitations that I found in my study. The *Mix it Up* program, running since 2006, ended in 2018. With more time, I might have been able to conduct a longitudinal study to follow the participants through the program and measure how perceptions of science/mathematics principals and the support they provide might change as participants continue to attend the professional development. I would also have been able to better correlate and validate the data collection instruments so that the teacher and principal inventories would address the exact same items. I would also have developed additional surveys based on findings and conducted interviews with more time available. The limitation of a small sample size also prevents my study from being used to make specific recommendations to principals regarding the importance of attending professional development with teachers. Finally, because of the termination of the program, this study would not be able to be replicated to confirm results.

Future Studies

Studies that could be conducted in the future by myself or other researchers to further the understanding of the role of principals in providing support to their teachers in science/mathematics instruction would include case studies conducted on science/mathematics principals. Ideally, the participants would all be from the same school district and be either all elementary principals or all middle school principals, but have different levels of attendance in a science/mathematics-specific professional development program with teachers. In this way, principal participants would all be facing similar external constraints and fewer extraneous variables would exist than in my study where principals came from different districts and different grade levels.

Implications

Because of the themes that I found when analyzing data, I suggest that by attending science/mathematics-specific professional development, principals are better able to identify and provide the specific science/mathematics support that teachers need in order to be successful in implementing effective science/mathematics instruction in their classrooms. For example, participants that had attended the professional development expressed qualities and behaviors that they found essential in effective science/mathematics principals including *principals' communication*, *principals' and teachers' knowledge*, and *principals providing a supportive STEM ethos/culture*, *principals protection of teachers' time*, and *principals providing resources/principals managing budget*. The practices mentioned by participants aligned closely to the best practices identified by *Mix it Up* to support and enhance science/mathematics instruction in the classroom.

As much as I would like this study to be strong enough to make recommendations to principals and districts, further studies like the ones listed above would need to be conducted to confirm the results of my study before making recommendations. Once additional studies have been conducted, recommendations could potentially be made to parties invested in furthering science/mathematics education to involve principals more in science/mathematics-specific professional development in order to enable principals to have a better understanding of what quality science/mathematics support is and how it can best be supported by principals. Constructionist (Vygotsky, 1978) and constructionist (Papert, 1991) theories support the idea that with knowledge constructed from personal experiences, principals will be better able to provide specific science/mathematics support that enables their teachers to better teach science/mathematics in the classroom.

I close with a quote from a principal participant that was relatively new to the *Mix it Up* program. She summarized the value of attending professional development with her teacher when she explained that:

> The surprise for me was how important it was that I attend and be part of this [professional development with teachers]. I didn't get it until I went and participated in what the teachers were doing. I know now how valuable the time spent in ensuring we are providing best practices for our teachers so they create learning environments that meet students' needs in science and math.

APPENDIX SECTION

APPENDIX A

Principal's Perception Inventory (PPI)

Name________________________ Date________________________

Campus______________________ Position_____________________

Part One: On a scale from 1-5, 1 being never and 5 being consistently, indicate the number that best describes your experiences over the past two years. There are nc right or wrong responses. What matters is that you are honest in representing your experiences.

Use the following question stem for the first 11 questions.
Note: STEM is science, technology, engineering, and math.

How often in the **past two years** have you….

1) …articulated a vision for STEM for a campus you serve/served/will serve?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on your experiences articulating a vision for STEM on your campus, providing specific examples when appropriate.

2) …envisioned how STEM embeds within the strategic plan for your campus?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on your vision of how STEM embeds within your campus' strategic plan. If possible, cite specific examples of STEM in your campus plan.

3) …asked for more information on STEM from STEM content-area experts?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Tell about a time when you asked for more information on STEM from content-area experts. Be sure to include details such as what you asked, of whom, and what the context was that prompted you to ask.

4) …examined campus space allocations with STEM teaching in mind?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Tell about a time when you examined campus space allocations with STEM teaching in mind. Be sure to include details such as what you examined, with whom, how you went about the examination, and what the context was that prompted you to do this. Discuss any projected renovations and their impact on STEM learning.

5) …included teachers at your campus in decisions about student successes in STEM?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Tell about a time when you included teachers at your campus in decisions about student successes in STEM. Be sure to include details such as what you asked, of whom, and what the context was that prompted you to ask.

6) …examined your campus' yearly budget allocations with STEM teaching/materials in mind?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Tell about a time when you examined your campus budget with STEM teaching and materials in mind. Be sure to include details such as what you examined, with whom, how you went about the examination, and what the context was that prompted you to do this.

7) …advocated for STEM-specific professional development (PD) in mind?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Tell about a time when you advocated for STEM-specific professional development. Be sure to include details such as what you advocated for, to whom, why, and what the context was that prompted you to do this. Discuss who makes STEM PD decisions, the principal or district.

8) … provided for protected TEKS-aligned instructional time so that teachers have adequate time to teach the material?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on how you have examined the master schedule to protect instructional time. Be sure to include details such as what you examined, with whom, how you went about the examination, and what the context was that prompted you to do this.

9) …analyzed horizontal alignment between math and science?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on how you have analyzed horizontal alignment between math and science. If you have analyzed the horizontal alignment, elaborate on any significant areas of concern you have identified.

10) …ensured that STEM-specific best practices are being used in STEM classrooms on your campus?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on how you ensured that these specific practices were being used in STEM classrooms on your campus. Be specific as to which STEM-specific best practices were being used and how they differed from general best practices.

11) … provided for all teachers at your campus to have access to a grade-level set of the TEKS-required equipment and materials?

1	2	3	4	5
never	rarely	occasionally	often	consistently

Elaborate on how you have addressed the TEKS requirement of specific grade-level materials/equipment.

Part Two: Respond to the following vignettes.

12) Read and respond to the following STEM-centered teacher meeting vignette.

Setting: A formal meeting in your office, scheduled a week in advance

Participants: You and Ms. Rodriguez, a fifth grade science teacher who is in her sixth year teaching, the second year at your campus

Dialogue:
Ms. Rodriguez: Thanks for taking time to meet with me. I'd like to talk with you about a possible new room assignment for next school year. I really want to use Cooperative Learning and frequent hands-on activities including lab and field investigations throughout the year. My current room set-up does not lend itself for cooperative grouping nor does it have space to conduct these types of high quality activities.

Extra Information
Constraint: All classrooms have already been assigned.

Your reply:

Your questions:

Your next course of action to address Ms. Rodriguez's concerns:

13) Read and respond to the following STEM-centered parent meeting vignette.

Setting: The school cafeteria hosting a "coffee with the principals" meeting open to the parents/guardians of any student in the middle school.

Participants: You, two other administrators, 16 parents and a few of their young children

Dialogue:
Dad: When will classrooms get new materials and equipment for science labs? My daughter is in Earth Science and she says they don't do labs. I asked Mr. Bloom (his daughter's science teacher) in an email why he doesn't do labs. He said all the current equipment is worn out, broken, or not reliable and that there are not enough consumable materials. Why is that? How will you fix this?

Extra Information
Constraint: There is not money set aside in this year's budget to buy these materials.

Your reply:

Your questions:

Your next course of action to address the parent's concerns:

Part Three: Respond to the following question in a brief reflective essay.

14) Who are you as a STEM leader on your campus?

APPENDIX B

STEM Empowering or Constraining Decisions by Administrators

Sandra West, Denise Kern, Sandra Browning, Mark Estrada, Laura Gibson, Deanna Juarez

sw04@txstate.edu

8-30-2018

mixitupscienceandmath.weebly.com

	Empower	**Constrain**
Familiarity w/STEM Best Practices	Very familiar with **STEM Best Practices** **Generalizes STEM Best Practices to General Best Practices** 3 principles, collaboration, etc. *(Most of this research is in our sessions' handouts)*	Unfamiliar with **STEM Best Practices** Insist on general "one size fits all" e.g. • Vocabulary 1st • use of key words in mathematics • *Direct Instruction* or *Inquiry* (5e) for every lesson • Objective on board that negates inquiry
Principals experiencing learning using STEM Best Practices	Understands & supports use of concrete experiences (manipulatives & labs, use of school grounds, etc.)	Sees little/no need for concrete learning experiences w/ manipulatives or equipment or materials Supports worksheets or test prep rather than problem solving. Doesn't fund materials/equipment.
Hiring	STEM content & pedagogy. Interview team (teachers & admin) Principals have total autonomy and support from central office for hiring decisions with HR carrying out details of principal decision	Generalists Alternative certified Little to no teacher input Teachers are hired through central office with little or no input of choice by principals
Departmentalization	Pros: Stronger content/pedagogy w/ either science or math or science/math specialists	5th grade Self-contained Departmentalize too early (3rd or 4th grade).

	Cons: Interdisciplinary connections (K-5 self-contained). Adequate materials. (6-8, either same discipline & different grades OR Sci /math at same grade)	Not allow teachers input on decision.
Team members	Complementary strengths, Teachers choose	Required Collaboration w/ Little/no expectation/training or consistent time
Materials/Equipment	Science TEKS require & mathematics TEKS suggest use of materials 1/student or 1 set/2-4 students. Enable next day purchases for expendables w/CC or reimbursement system. High quality materials are purchased with teacher input. inventoried, & sustained from year to year.	Thinking technology can replace concrete experiences – a silver bullet No class set. Teachers demo rather than have the manipulatives in students' hands, or they show pictures. This does not address tactile-kinesthetic learners, ELLs. Teachers spend their own $ on materials and supplies, or students are denied the learning experience due to lack of resources.
Room Assignment	STEM-designed rooms. Science & mathematics in adjacent rooms, same hallway or as close as possible to encourage ongoing collaboration	General education rooms – too small, lack horizontal work surface area, water, storage, electrical outlets, etc. See TEA science facilities rules TAC rule 61.1036, 2004
Scheduling	Consecutive courses *(ex. periods 1-4 – Science 6, periods 5-8 – Science 7)* Provide end-of-day planning to facilitate setting up for next-day concrete experiences.	Alternate courses among periods *(1st period – Science 6, 2nd period – Science 7, etc.)*
Protect Instructional Time	Scope & Sequence (S&S), school schedule, adequate minutes, not just days. Minimum 170 days/8,500 minutes Reduce/eliminate classroom interruptions throughout the day	Loss of instructional time, e.g. • S&S (inc.15 days Safety/use of Equipment) • 9 weeks of STAAR review • No science in grades 3 & 4 all year or only in Fall

	such as impromptu pep rallies/assemblies or picture day	
Building a Community of Practice (CoP)	Develop Social/Relationships and trust No intimidation Enable collaboration	Speak of <u>need</u> of CoP, but do not enable (time, schedule, expect, hire, etc.) Top down attitude
"Love Languages"	1. "Acts of service" 2. "Words of affirmation"	Fail to budget and purchase science/mathematics equipment/materials/ manipulatives or consumables for teachers to teach TEKS NO PD for teachers and staff planned ongoing support for use of new equipment, manipulatives, materials and consumables Few words of appreciation or compliments
Instructional Coaches	Strong content & pedagogy • 5 yrs. teaching experience • 2 yrs. leadership role • trained in coaching	Too little experience to have creditability and expertise ultimately sabotages the program. ICs frequently used as AP, performing paperwork tasks rather than classroom observing & coaching
Test Practice	Teaching TEKS to correct cognitive level enables students to learn/ remember concepts. Need only 2 weeks of review before STAAR test (or ISD assessment) Multiple assessments used and administered unobtrusively as part of learning process: formative, observations, projects, etc.	STAAR review -3-9 weeks resulting in lost instructional time. Test prep worksheet packets used most of the time Teaching only Readiness Standards before STAAR & Supporting standards after STAAR
Professional Development (PD)	Specific for teaching assignment Effective research-based • long term, intense (1 yr./100 hrs.), ongoing (2hr/session outside of school day)	General PD not specific for teaching assignment PD during conference/planning time or during school day Short 6-hr. sessions filled with activities that lack content

	Additional paid work days for PD attendance "Whole Child" PD focusing on integration of TEKS between teams, grade levels and campus Collaborative teaching emphasized	pedagogy or conceptual understanding, and that sometimes do not model science or mathematics Best Practices. Many of the activities are left on shelf, forgotten & not implemented if not tied to S&S and TEKS.
TEKS	Ensure teachers clearly understand the TEKS. Refer to national standards (BSL, NSES, *Framework*, NGSS, NCTM) Science & Mathematics Research/Best Practices to implement TEKS. *Long term (over 1 yr.) & intense (over 100 hrs) to be effective (impact student learning). Mix research: over 1.5 yrs & 170 hrs of PD*	TEKS not unpacked (explained) and not linked to national standards (NCTM or NGSS, not Common Core) for teachers due to lack of long-term, intense, focused PD, lack of collaborative time, short/shallow 6 hour PD sessions
TEKS-based lessons	Lesson plans that clearly demonstrate the lesson enables students to understand the TEKS. Provide planning time that is adequate for teachers to analyze standards prior to their planning of lessons.	Using commercial products that may be inaccurate, not TEKS-based, or far beyond the TEKS. Teaching all concepts in a TEKS in 1 lesson (more than 1 concept/lesson – See *3 Lesson Planning Principles*).
Science taught K-5	K-12	Deletes science from 1 or more of grades K-4
Mathematics/Science Horizontal alignment	Mathematics' skill learned before using in science. Review mathematics & science S&S to identify where mathematics is used in science & revise science S&S.	Mathematics skill used in science before student learns in mathematics class. Lack of collaboration & alignment between science & mathematics.
Confusing Words in Mathematics & Science	Identify the synonyms and homonyms with explicit instruction in both science & mathematics classrooms	Lack of collaboration between science & mathematics. Students confused about similarities & differences between science & mathematics vocabulary.

Administration stability	Keep effective administrators & programs in place for 3+ years. Campus Culture and Climate top priority Make Data-Driven decisions. Certification obtained from a strong institution	Administrator for less than two years in current position Certificate obtained from alternative program without strong success data Campus Culture and Climate low priority Limited leadership skills Limited and inadequate PD available for administrator
Science Facilities Design TAC rule 61.1036, 2004	Facilities should enable Best Practices and effective science & mathematics instruction	Facilities should not impede science or mathematics student learning
School Culture & Climate	Social/Emotional Learning (SEL) is a priority underlying "How we do what we do." Systems in place for helping students belong, problem solve, set goals for success and developing a strong feeling of attachment to the school community. Build on the previous campus successes using existing systems that are working well. Acknowledge high-performing staff and use their strengths to enhance student learning. Effective use of school wide video announcements All staff model superb customer service, using the same behavior standards used for students creating a welcoming environment and attitude throughout the campus.	SEL is not directly included in campus culture and climate. No articulated system in place for helping students belong, problem solve, set goals for success and for developing a strong feeling of attachment to the school community. Adopt the system without follow-through. Inconsistent, ongoing PD Campus-level lack of expertise in staff PD for behavior systems. Demonize the previous administration/system. Re-invent the wheel. Undo previous work only because it was accomplished under the previous administration. Poor customer service from a number of staff Lack of consistent positive behavior modeled by adults and students
School-Wide and District-Wide Behavior Systems	Positive Discipline, Restorative Discipline, Positive Behavior Intervention Supports (PBIS) or similar system framework in place Effective use of school wide video announcements	Inconsistent implementation at administration & teacher level Different from school to school within district. Punitive practices used much of the time.

State Mandate Compliance	Student learning is the focus. District leadership takes the housekeeping details off of principals' plates. Effective use of school wide video announcements	Compliance is the focus hoping student achievement increases as high level of compliance is reached.
Teacher Evaluation	Coaching model used. Teachers enjoy the process and get frequent, high-quality feedback. Administrator uses best practices for teacher learning, modeling what is expected for teachers to do as well. Teachers feel empowered (Big Circle: Little Circle: Unequal psychological relationships)	Teacher perception of being micro-managed. Literal observation based on the form with little to no consideration of research-based best practices Data generated is used to categorize "good teachers" and "bad teachers", and hiring/firing decisions, teacher assignments are made based upon this data. Climate of FEAR "Gotcha" culture abounds Teachers are intimidated (Big Circle: Little Circle: Unequal psychological relationships)
District Use of Data	Use multiple data sources - both academic & SEL. Focus on whole child. Student-centered decisions expected for each child Data programs and software are up to date, effective and easy for students, teachers and parents to use	Focus primarily on STAAR data Lack of formative common assessments Lack of classroom teacher created formative assessments Digital tests BOY website crashed Outdated or ineffective software and tech used because it is "free" No parental use/availability Requires teachers lots of additional time to enter data because the software is not compatible with the other data programs
Teacher Quality	High-performing teachers are recognized and supported. Campus climate is supportive, intellectually stimulating, and consistent, with on-going, high quality professional development. Low teacher mobility rate.	Low-performing teachers are not held accountable to high standards. Campus climate is poor. Teachers view the instructional leader as non-supportive. Teachers are afraid.

	Multiple leadership opportunities encouraged and available for teachers.	Teachers have little or no access to consistent, high-quality professional development. High mobility of teachers.
District Level Curriculum Leadership	Common assessments are collaboratively created with campus and district personnel, are horizontally and vertically aligned with the standards, use multiple formats, and demonstrate what kids know and are able to do.	Common assessments are not aligned with standards, format is low level, and look like a standardized test. Students feel they only practice taking the test rather than learn. Test may or may not demonstrate what kids know and are able to do.
Class Configuration	Heterogeneously grouping (PK-8) providing many opportunities for role-modeling. Balanced with sub-pops. Number of students is appropriate for use of best practices.	Ability grouped or sub-pops are clustered or grouped separately. Class sizes are unbalanced.
Teaching Assignments	Teachers are involved in the assignment process and are able to choose where and what they want to teach as much as possible Coaching model is used with fidelity. Coaches/mentors are highly capable and effective master teachers.	Teachers are assigned their class without input or consideration to their strengths or choice. Mentoring is non-existent or happens in name only.
Student Teachers	Student teachers' needs and cooperating teachers' capacities are priorities when placing student teachers, interns and teacher fellows.	Student teachers are assigned to poor cooperating teachers to "give the classroom students a better experience because the teacher of record is not capable".
Staff Development	Professional Development is ongoing, well-designed, aligned with campus staff needs, well-delivered, models use of research-based best practices, and collaboratively taught. Reflections are used to tweak and improve.	PD is not planned. PD is not delivered. Best practices are not modeled. PD happens inconsistently or not at all. PD inconsistent with teacher needs. "One size fits all" approach is put forth.

	PD is well analyzed, the data is used and successes are celebrated.	
Collaborative Teaching Teams	Campus organized into teaching teams Co-teaching and/or collaborative teaching models used Ongoing PD supporting teaching teams Action research by teaching teams implemented and shared in multiple locations	Classroom teachers have little or no opportunity for collaboration No research opportunities No ongoing PD supporting co-teaching or collaborative teaching
Librarian	Library is the center for learning on campus Librarian is a master teacher, media specialist; and supports curricular integration needs for teachers and students with materials and experiences in the library. Librarian is an active member of campus leadership team.	Librarian is placed in the master schedule as a "specials" teacher so CORE teachers get common planning time.
Counselor	Counselor is an active member of campus team. Heavy involvement with parents, teachers, campus staff and community members. Counsels students in classroom guidance, small groups and individual sessions. Collaborates with administration, social workers, nurses, doctors, etc. in student crisis issues and situations Counselor student teacher ratio 1:350 Works with campus leadership implementing Restorative Discipline campus wide **HAS NO ROLE IN TEST ADMINISTRATION OTHER THAN EXTRA HELP ON**	Counselor is placed in the master schedule as a "specials" teacher so CORE teachers get common planning time. Job of counselor becomes academic advisor and test administrator. Student to counselor ratio 1: 350 state recommendation not considered

	STATE MANDATED TEST ADMINISTRATION DAY	
Assistant principal	Assistant principal(s) active member of campus leadership team Works with campus leadership implementing Restorative Discipline campus wide Student behavior is taught as part of overall culture and climate of school Out of control student behavior seen as “teachable moment”, respect and “fixing the mistake”	Assistant principal is the “enforcer” Assures compliance to district “Code of Conduct” ISS model used to change behavior Consequence and punishment used to change behavior Out of control student behavior seen as disrespectful, needing compliance enforcement

Sandra West, Ph. D., Dept. of Biology, Texas State University, sw04@txstate.edu
Denise Kern, Ph. D., Retired teacher, counselor, principal; current school board trustee drdenisekern@gvtc.com
Sandra Browning, Ph. D., Dept. of Teaching & Learning, University of Houston-Clear Lake, browning@uhcl.edu
Mark Estrada Superintendent, mark.estrada@lockhart.txed.net
Laura Gibson, Science Master Teacher, lauralafon@me.com
Deanna Juarez, Principal, Navarro Elementary, Deanna.juarez@lockart.txed.net

This presentation is based in part on a project funded by the
Teacher Quality Grants program at the Texas Higher Education Coordinating Board (539 TSU) supported through federal funds under NCLB Title II, Part A.
Texas State University

APPENDIX C

Teacher's Perceptions of Principal's Practices (TP3)

Teacher's name: _______________________________ School year_________________________

Grade level(s) taught__________________ Subject(s) taught _______________________________

"An organization is the lengthened shadow of one man." Ralph Waldo Emerson

Mix It Up Collaborative Science and Math provides professional development for our administrative leadership as well as our teachers. This professional development includes individualized mentoring and coaching for your principal. This survey is used to gather data for coaching purposes only. Your answers will be coded and summarized prior to individual discussions with each principal and will not be identifiable to your principal.

Please complete the following survey concerning your opinions and perceptions of professional and instructional support from your building principal.

Professional support:

1. I see my principal acting as an instructional leader:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

2. I see my principal including teachers in decisions about teaching assignments:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

3. I see my principal creating a positive school culture and climate:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

4. I see my principal working collaboratively with district leadership:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

5. I see my principal trusting my professional judgment and use of best practices:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

6. I see my principal modelling collaborative learning and teaching:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

7. I see my principal "following through" with campus initiatives:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

8. My principal's individual observations and feedback for me happens:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

9. My principal assures collaborative planning time with my teaching colleagues happens:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

10. My principal assures focused professional development based upon best practices happens on my campus:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

11. My principal assures materials, resources and supplies specific to my teaching assignment are provided:

1	2	3	4	5
Never	Rarely	Sometimes	Often	Always

Instructional support:

12. The materials, resources and supplies currently provided for use in my classroom:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

13. My principal's expectation of the use of formative assessments:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

14. My principal's use of district created benchmark assessments:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

15. My principal's knowledge of research based best practices for math instruction:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

16. My principal's knowledge of research based best practices for science instruction:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

17. My principal's behavior expectations for all students on my campus:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

18. My principal's system wide use of instructional time on my campus:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

19. My principal's expectations and use of technology in my classroom:

1	2	3	4	5
Impedes my instruction	Provides no support for instruction	Provides limited support for instruction	Provides adequate support for instruction	Provides full support and enriches instruction

Please share any additional information which might be helpful as Mix It Up assists your principal in supporting Mix you as a professional educator.

APPENDIX D

Principal's Role Survey

Principal's Role Survey

MIX It Up

Dr. Sandra West
Texas State University

MIX It Up has created this survey to allow you to reflect on the characteristics you feel are needed in an effective STEM leader. Please answer the following questions about STEM principals as honestly as possible. These responses are anonymous and will not be shared with your principal.

1. What do you feel are practices, attitudes, or behaviors that are essential in order for a principal to ensure effective STEM instruction on their campus?

2. What is the principal's role as a leader in effective STEM instruction?

Additional Comments

Thank you very much for taking the time to complete this survey. Your feedback is valued and very much appreciated!

REFERENCES

American Association for the Advancement of Science. (1990). *Science for all Americans.* New York: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy* New York, NY: Oxford University Press.

Anderson, R. D. (2002). Reforming science teaching: what research says about inquiry. *Journal Of Science Teacher Education, 13(1),* 1-12.

Austin, J. D., Converse, R. E., Sass, R. L., & Tomlins, R. (1992). Coordinating secondary school science and mathematics. *School Science and Mathematics, 92*(2), 64-68.

Banilower, E. R., Heck, D. J., & Weiss, I. R. (2007). Can Professional Development Make the Vision of the Standards a Reality? The Impact of the National Science Foundation's Local Science and Mathematics Change through Teacher Enhancement Initiative. *Journal of Research in Science Teaching*, *44*(3), 375-395.

Basista, B., & Matthews, S. (2002). Integrated science and math professional development programs. *School Science and Mathematics*, *102*(7), 359-370.

Basista, B., Tomlin, J., Pennington, K., & Pugh, D. (2001). Inuiry-based integrated science and mathematics professional development program. *Education*, *121*(3), 615-624.

Bossé, M. J., Lee, T. D., Swinson, M., & Faulconer, J. (2010). The NCTM process standards and the five Es of science: Connecting math and science. *School Science and Mathematics*, *110*(5), 262-276.

Butler, L. (2012). Learner-Centered Teaching; Five Key Changes to Practice. *Journal of Human Services, 32(1),* 92-94.

Bybee, R. (2000). Teaching science as inquiry. In J. Minstrell & E. H. van Zee (Eds.), Inquiring into inquiry learning and teaching in science (pp. 21-46). Washington, DC: American Association for the Advancement of Science.

Carver, C. L. (2010). Principals + Algebra (- Fear) = Instructional Leadership. *Journal of Staff Development*, *31*(5), 30-33.

Crawford, B. A., Zembal-Saul, C., Munford, D., & Friedrichsen, P. (2004). Confronting prospective teachers' ideas of evolution and scientific inquiry using technology and inquiry-based tasks. *Journal of Research in Science Teaching*, 42(6), 613-637

Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed-methods approaches.* 4th ed. Thousand Oaks, California: SAGE Publications.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry & research design choosing among five approaches*. Thousand Oaks, California: SAGE publications.

Dong, Y., Xu, C., Song, X., Fu, Q., Chai, C. S., & Huang, Y. (2019). Exploring the Effects of Contextual Factors on In-Service Teachers' Engagement in STEM Teaching. *Asia-Pacific Education Researcher, 28*(1), 25-34.

EL-Deghaidy, H., Mansour, N., Alzaghibi, M., & Alhammad, K. (2017). Context of STEM Integration in Schools: Views from In-Service Science Teachers. *EURASIA Journal of Mathematics, Science & Technology Education*, *13*(6), 2459–2484.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What Makes Professional Development Effective? Results from a National Sample of Teachers. *American Educational Research Journal, 38(4*), 915-45.

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2009). *Highlights from TIMSS 2007: Mathematics and science achievement of U.S. fourth- and eighth-grade students in an international context*. Washington, DC: National Center for Education Statistics.

Havice, W., Havice, P., Waugaman, C., & Walker, K. (2018). Evaluating the Effectiveness of Integrative STEM Education: Teacher and Administrator Professional Development. *Journal of Technology Education*, *29*(2), 73–90.

Herrington, D. & Daubenmire, P. L. (2016). No Teacher Is an Island: Bridging the Gap between Teachers' Professional Practice and Research Findings. *Journal of Chemical Education*, *93*(8), 1371-1376.

Icel, M. (2018). Implementation of STEM Policy: A Case Study of a STEM-Focused Urban Charter School. *Journal of STEM Education: Innovations and Research*, *19*(3), 7–13.

Knipprath, H., Thibaut, L., Dehaene, W., & Depaepe, F. (2018). How school context and personal factors relate to teachers' attitudes toward teaching integrated STEM. *International Journal of Technology and Design Education*, *28* (3), 631-651.

Krajcik, J., Blumenfeld, P., Marx, R., & Soloway, E. (2000). Instructional, curricular, and technological supports for inquiry in science classrooms. In J. Minstrell & E. H. van Zee (Eds.), Inquiring into inquiry learning and teaching in science (pp. 283-315). Washington, DC: American Association for the Advancement of Science.

Lincoln, Y. & Guba, E. (1985). *Naturalistic Inquiry*. Thousand Oaks, CA, US: Sage Publications, Inc.

McBride, J. W. & Silverman, F. L. (1991). Integrating elementary and middle school science and Mathematics. *School Science and Mathematics, 91*(7), 285- 292.

McMillan, J. H. (2012). *Educational research: Fundamentals for the consumer*. Boston: Pearson.

Moustakas, C. E. (1994). *Phenomenological research methods*. Thousand Oaks, CA, US: Sage Publications, Inc.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: National Council of Teachers of Mathematics.

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010) *Common Core State Standards for Mathematics.* Washington D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press

National Research Council. (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning*. Washington, DC: National Academic Press

National Research Council. (2012). *A Framework for K-12 Science Education* Washington, DC: National Academic Press

National Science Foundation. (2007). *A national action plan for addressing the critical needs of the U.S. science, technology, engineering, and mathematics education.* NSB-070114. Retrieved from http://www.nsf.gov/nsb/edu_com/draft_science and mathematics_report.pdf

NGSS Lead States. (2013). *Next generation science standards: For states, by state*s. Washington, DC: The National Academies Press.

Offer, J., & Mireles, S. V. (2009). Mix It Up: Teachers' Beliefs on Mixing Mathematics and Science. *School Science and Mathematics, 109(3),* 146-152.

Papert, S. (1991). *Constructionism*. New York: Ablex.

Park Rogers, M. A., Volkmann, M. J., & Abell, S. K. (2007). Science and Mathematics--A Natural Connection. *Science and Children, 45(2),* 60-61.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning Styles: Concepts and Evidence. *Psychological Science in the Public Interest*, *9*(3), 105–119

Peters, T., Schubeck, K., & Hopkins, K. (1995). A thematic approach: Theory and practice at the Aleknagik school. *Phi Delta Kappan*, 76, 633-636

Sandholtz, J. H., & Ringstaff, C. (2016). The Influence of Contextual Factors on the Sustainability of Professional Development Outcomes. *Journal of Science Teacher Education*, *27*(2), 205-226

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing Teacher Education and Professional Development Needs for the Implementation of Integrated Approaches to STEM Education. *International Journal of STEM Education*, *4*.

Van de Walle, J. A., Karp, K.S., & Bay Williams, J.M. (2016). *Elementary and middle school mathematics: Teaching developmentally* (7th ed.). Upper Saddle River, NJ: Pearson.

Vásquez-Mireles, S., & West, S. (2007). Mix It Up. *Science Teacher, 74(2),* 47-49.

Von Secker, C. (2002). Effects of inquiry-based teacher practices on science excellence and equity. *The Journal of Educational Research*, 95(3), 151-160.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wenner, J. A. (2017). Urban Elementary Science Teacher Leaders: Responsibilities, Supports, and Needs. *Science Educator*, *25*(2), 117-125.

West, S. & Tooke, D.J. (2001). Science and Math TEKS Correlations. *The Texas Science Teacher.* 30(1)

West, S. & Tooke, D. J. (2003). K-8 Science and Mathematics Integration: Doable? Desirable? *The Texas Science Teacher,* 32(1):17-26.

West, S., Vásquez-Mireles, S., & Coker, C. (2006). Math and/or Science Education: Separate or Integrate? *Journal of Mathematical Science and Mathematics Education* 1(2).