2017

Middle School Mathematics Teachers' Perspectives on Instructional Practices

Cindy Ziegler
Walden University

Walden University

COLLEGE OF EDUCATION

This is to certify that the doctoral study by

Cindy Ziegler

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Amy Gaskins, Committee Chairperson, Education Faculty
Dr. Jerita Whaley, Committee Member, Education Faculty
Dr. Michelle Brown, University Reviewer, Education Faculty

Chief Academic Officer

Eric Riedel, Ph.D.
Walden University
2017

Abstract

Middle School Mathematics Teachers' Perspectives on

Instructional Practices

by

Cindy Ziegler

MA, Walden University, 2004

BS, Texas A&M University, 1990

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

March 2017

Abstract

In a local middle school, students were not meeting standards on the state mathematics tests. The purpose of this qualitative study was to explore mathematics teachers' perspectives on effective mathematics instruction vis-à-vis the principles of the National Council of Teachers of Mathematics (NCTM). Within this framework, the 6 principles in the creation of quality mathematics programs included equity, curriculum, teaching, learning, assessment, and technology. Seven teachers from around the country participated; all met the criteria of a graduate degree in education, at least 5 years of experience teaching adolescent learners, and at least 3 years teaching mathematics. Participants were surveyed about their perspectives using a modified Delphi method. In Round 1, they listed practices that they believed were helpful in all NCTM content standards. In Round 2, they ranked all of the practices and provided rationales. In Round 3, they viewed Round 2 rankings/rationale and then rated the practices a last time. Qualitative content analysis was used to analyze Round 1; descriptive analysis was used to analyze ranking data from Rounds 2 and 3. The results revealed the most effective instructional practices for middle school mathematics in each of the NCTM content standards. With that information, a training plan was developed to give local mathematics teachers a tool with which to analyze their instructional practices and then integrate the effective ones based on the modified Delphi study results to improve their students' achievement. Implications for positive social change include providing the local site with a research-based teacher training plan to improve mathematics instruction and potentially improve student achievement.

Middle School Mathematics Teachers Panel Perspectives of Instructional Practices

Cindy Ziegler

MA, Walden University, 2004

BS, Texas A&M University, 1990

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

March 2017

Dedication

There are many people who have helped me along the way to completing my doctoral study. Some people have motivated me, some have helped me with wonderful advice and edits, and some have done both for me.

The first person is the most important to both this study and my life. My husband encouraged and motivated me even when it looked like I might want to give up. He is my rock, and I love and respect him very much!

My son has also been a major motivating factor for me, and I will be so happy to be able to devote more time to him now that this process is finished. Being a role model for him is very important for me, and I hope that seeing his mother complete her doctorate will inspire him to be a life-long learner too. I love him more than words can say!

Finally, my committee, including Dr. Gaskins and my URR, Dr. Brown, was very important to helping me complete this process. Their comments and guidance were invaluable and helped me to create a study that makes me feel proud!

Acknowledgments

I would like to acknowledge many people in my life who have encouraged me to follow the long road that led to this study being published. First and foremost, my husband has been my rock through the whole process. My son, who was adopted as a baby right before I began the study, inspires me to be a role model and life-long learner. I could not have completed the process without my doctoral chair, Dr. Gaskins, who, thankfully, took me on after a very difficult and demoralizing prior experience with this study. Finally, my family, including my sister and parents never let me give up, and believe me, there were times that I wanted to move on.

Table of Contents

List of Tables

Section 1: The Problem

Introduction

The competency to solve various mathematics problems is critical to a student's educational success. Solving mathematics problems dependsent on a student's basic understanding and application of mathematics concepts as well as critical thinking skills (Wilson, 2009). Mastery of these concepts and the skills are critical to a student's future educational success.

In today's classroom, middle school students are deficient in their ability to solve grade-appropriate minimum mathematics competencies problems due to weak problem-solving and critical thinking skills. For these students, the challenges of solving mathematics problems begin in the early grades and are compounded as they move into the higher grades (Cotik & Zujlan, 2009). In the early grades, students initially learn to solve simple mathematics problems through various exploratory instructional mathematics practices: Children use their senses and manipulatives to count, add, subtract, and multiply (Robelen, 2012). Teachers may start with a variety of activities which could include rhymes and songs, riddles and clapping games to introduce the basics of problem solving so that students are engaged in problem solving (Rapp, 2011). These activities allow the students to problem solve by using conceptual understanding techniques. Once students are introduced to these exploratory instructional mathematics practices, they are then expected to work basic computations of addition, subtraction, multiplication, and division.

But in the upper elementary grades and middle school, many teachers strive to teach mathematical concepts from a theoretical perspective without first engaging learners or appealing to the sensory aspects of the learning process (Holmstrom, 2010). An example of this could include teaching students traditional methods for multi-digit multiplication without showing them conceptual methods such as using an area model. This shift in instructional practice may leave students questioning their ability to use critical thinking skills to solve mathematical problems (Holmstrom, 2010). The focus on traditional, rather than multisensory instructional practices, can reduce students' confidence in problem solving and performance (Rapp, 2011). For some students, the result might be poor mathematics performance.

Data obtained from 2011 state standardized tests revealed that some students in a Colorado urban school district struggle with demonstrating mastery of required mathematics concepts. An average of 37% of seventh grade and eighth grade students in this district failed to meet minimum mathematics competencies, as measured by the 2011 state standardized tests (Colorado Department of Education [CDE], 2011). Based on this result, this project study gathered data from a panel of middle school mathematics teachers on the instructional practices that could improve student mastery of mathematics concepts and content related to the middle school National Council of Teachers of Mathematics (NCTM) Content Standards. By using appropriate problem-solving strategies for learning mathematics concepts, a student may more easily master the complex mathematics concepts presented in the middle school mathematics content standards of the NCTM middle school mathematics content standards. This student mastery could also impact mathematics achievement scores (Cole, 2010). Educators may benefit by learning about instructional mathematics practices that have proven successful for other educators.

Based on a literature review of instructional practices for middle school mathematics students, this project study explored the perspectives of a panel of middle school mathematics teachers on instructional practices for learning the concepts and content of middle school mathematics. The perspectives were used to inform educators and they can help plan future mathematics instruction. Additionally, these instructional matthematics practices may ensure alignment with NCTM content standards of middle school mathematics.

In the following sections, Definition of the Problem, Rationale, Evidence of the Problem at the Local Level, Evidence of the Problem from the Professional Literature, Definitions, Significance, and Guiding/Research Questions, the problem of low levels of mathematics achievement for middle school students at the local and national level is discussed. It includes a literature review and a theoretical framework that is related to mathematics comprehension. Finally, the implications of this project are discussed.

Definition of the Problem

In their initial years of education, teachers are helping students to develop competencies necessary to solve basic mathematics problems. During this time, students use manipulatives for a visual and kinesthetic way to learn; manipulatives help them to retain the concepts (Robelen, 2012). Visual and kinesthetic instructional mathematics practices are examples of sound, instructional mathematics practices that are used help students master difficult concepts. Students must learn visual and kinesthetic instructional mathematics practices if they are to expand their skills and move forward in the learning process (Rutherford et al., 2010).

Instructional mathematics practices extend into all mathematics areas as well as other academic subjects . As students advance through middle school, some students retain the ability to apply the instructional mathematics practices necessary to solve complex problems. Others students emerge with a deficit in using what they have learned from various instructional mathematics practices or transferring them to more complex problems or problems in different types of mathematics. According to Rutherford et al. (2010), some students consistently struggle to solve mathematics problems and are often unable to understand the mathematics concepts necessary for success in various types of mathematics or in practical applications. These students must navigate complex mathematics problems using only traditional instructional mathematics practices (Cotik & Zujlan, 2009). These traditional methods do not help students gain a deep level of mathematics concepts. Without more appropriate instructional mathematics practices, students may become disheartened, stymied, and exhausted by what they consider to be a series of random symbols and variables because they lack the critical thinking skills, problem-solving skills, or ability to understand the mathematics concpets required to reach solutions (Erden & Akgül, 2010).

Instructional mathematics practices should be specifically taught. Some middle school mathematics teachers may need more information about these alternative teaching approaches that could improve student achievement on mathematics assessments

(Robelen, 2012). Although some mathematics educators are successful in explaining difficult concepts, these same educators may not know about newer instructional practices or they may need practice in helping students grasp the concepts in all areas of mathematics (Perrit, 2010).

For the majority of students, mathematics achievement at the middle school level may be part of a nationwide and international issue. While some gains have been made in recent years, middle school students in the United States are behind at least eight other countries in mathematics achievement (McKinney & Frazier, 2008). The gap includes skills in number sense (numbers and operations), algebra, geometry, measurement, data analysis, and probability. If middle school students in the United States are to compete in a worldwide economy, the gap needs to narrowed or closed.

Consistent with nationwide mathematics statistics, one Colorado urban school district is dealing with these same obstacles. Its students are evaluated on their ability to solve mathematics problems measuring state standards, including all of the types of mathematics (CDE, 2011). In 2011, 36% of urban Colorado eighth graders scored Proficient or higher on the Colorado Student Assessment Program (CSAP, CDE, 2011). Although the 2011 eighth grade mathematics CSAP scores have improved since 2009, these data still indicate that 64% of urban students tested below the Proficient level. These scores indicate a need for appropriate instructional mathematics practices that help all students master abstract and more difficult middle school mathematics concepts. If these practices were infused successfully into existing curricula, gains could decrease the achievement gap and could encourage student proficiency in mathematics.

Rationale

Evidence of the Problem at the Local Level

The CDE outlined the Colorado State Standards, including information all elementary and secondary students should retain as a product of their learning in a Colorado public school (CDE, 2011). This framework includes standards that were created using the NCTM middle school mathematics content standards /framework and the Core Content standards. Each year, parts of the Colorado Student Assessment Program (CSAP) are administered to students in Grades 3 through 10, and evaluate a student's level of achievement in four subjects: reading, math, science, and writing (CDE, 2011). Outcomes are categorized as *unsatisfactory, partially proficient, proficient,* or *advanced* (CDE, 2011). Partially proficient or unsatisfactory indicates that a student has not met the minimum expectations (CDE, 2011).

Based on data analysis, some middle school students at a Colorado urban school district struggle to fully comprehend concepts in mathematics as evidenced through local test scores from the CSAP (CDE, 2011). For instance, in this specific Colorado urban school district, data from the mathematics CSAP data in 2011 revealed that an average of 37% of seventh and eighth grade students scored at the Proficient level or higher (CDE, 2011). According to these data, 63% of the middle school students in this district did not pass the mathematics assessment in 2011. These data indicate a potential gap in student learning and a failure to meet minimum requirements of the standards.

Even though inner city schools have demonstrated small gains in mathematics achievement, instructional practice needs to be addressed to make bigger gains

(McKinney & Frazier, 2008). This study solicited feedback from a panel of middle school mathematics teachers on which instructional mathematics practices would help students to better understand middle school mathematic instruction. By means of the panel, I collected research-based instructional mathematics practices that follow best practice and align with the concepts taught and Colorado's mathematics standards, which, ultimately, may improve middle school students' mathematics achievement. The results of the study are expected to help teachers improve students' understanding of middle school mathematics concepts.

Evidence of the Problem from the Professional Literature

Obstacles to student mastery of middle school mathematics concepts might be due to a scarcity in professional development training guides that is not useful for middle school teachers providing effective instructional mathematics practices (NCTM, 2000). Obstacles might also be due to an increase in the level of student frustration when performing more complex mathematics problems (Erden & Akgül, 2010) and the persistent use of mostly traditional instructional methods to teach students how to solve mathematics problems (Holmstom, 2010). When these factors are combined, student mastery of mathematics concepts may be limited.

Student achievement in all mathematics areas requires mathematics teachers to have a thorough knowledge and the ability to successfully teach the instructional mathemtaics practices necessary for students to solve complex mathematics problems. Many of these teachers are unapprised of the significant role these mathematics instructional strategies play as they relate to student success, ability, and learning (Cave

& Brown, 2010). Mathematics teachers may be unaware of mathematics instructional strategies and instructional methods that, once demonstrated, would empower some students to grasp complex mathematics problems successfully (Erden & Akgül, 2010). Other teachers may be confronted with pressure to finish their mathematics curricula within the school calendar, and may not deem mathematics instructional strategies as a priority in their classrooms (Rapp, 2011).

Combined with day-to-day teaching hurdles, inadequate opportunities for professional development exist for mathematics teachers who hope to effectively integrate mathematics instructional strategies into their curricula (Erden & Akgül, 2010). Perrit (2010) affirmed that it is the obligation of all teachers to inspire and use a variety of instructional strategies to help students in becoming stronger mathematics students. Although mathematics teachers may be considered experts in their fields, they may face struggles in explaining and teaching mathematics content to students as a consequence of a deficiency of knowledge and time to incorporate effective mathematics instructional strategies into their curriculum.

The selection and use of effective mathematics instructional strategies in middle school is lacking, in spite of federal and other programs implemented to enhance mathematics instruction (Rutherford et al., 2010). Bottge, Rueda, Grant, Stephens, and Laroque (2010) asserted that as students advance through their elementary school career, they are progressively exposed to more complex mathematics problems. According to Robelen (2012), much consideration has been given to the best mathematics instructional practices that focus on elementary students, however, little has been given to middle school students struggling with mathematics. Research through the National Mathematics Advisory Panel (NMAP) demonstrated that as students arrive at their middle and high school experiences, much elementary mathematics instruction supports are not available (NMAP, 2008). These supports can include strategies such as active learning, visual support, kinesthetic support with manipulatives, and musical mathematics songs to help students remember information. Many students will have moved on to challenging disciplinary NCTM middle school mathematics content standards using only traditional instructional strategies to solve problems.

The capacity to decipher complex mathematics problems is a fundamental component in most subject areas and students are required to solve problems in many different strands of mathematics throughout their elementary and secondary school experiences (Bottge et al., 2010). According to Erden and Akgül (2010), many middle school students fail to grasp the material or select not to complete the assignments because they lack essential mathematics strategies or select inappropriate mathematics instructional strategies needed to solve grade-level mathematics problems. Mathematics in a variety of strands such as geometry and probability may require its own specialized mathematics instructional strategies (Kang & Zentall, 2011). Although students may exhibit proficiency in some strands of mathematics such as number sense (numbers and operations), their proficiency to solve problems in other strands of mathematics may be unsuccessful, resulting in gaps in mathematics content area learning.

For some middle school students, comprehending complex mathematics problems is taxing. Likewise, many of their mathematics teachers may feel unprepared to teach outside of traditional mathematics instructional strategies. Combined with evidence from professional literature and standardized test figures from a specific Colorado urban school district, the problem of trying to solve complex mathematics problems in middle school mathematics and higher has endured for many years. During this time, some students have not reached minimum mathematics competency levels and as an outcome, may have gaps in their learning.

Definitions

Terms used in this project study are as follows:

Colorado Student Assessment Program (CSAP): According to the Colorado Department of Education (2011), CSAP tests students in Grades 3-10 in reading, writing, and mathematics. CSAP also tests students in science in Grades 5 and 8.

Multiple Intelligences (MI): The MI theory includes nine intelligences that could be identified as strengths in students' learning. The intelligences are linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, naturalistic, interpersonal, intrapersonal, and existential (Gardner, 2006).

Standards: NCTM middle school mathematics content standard used in this are from NCTM (2000) and refer to the concepts students should master in mathematics including algebra, numbers and operations, geometry, measurement, data analysis and probability and process.

Instructional mathematics practice: Instructional mathematics practices (Alberta Learning, 2002) are methods teachers use to help students turn out to be strategic, autonomous students. These practices help students to concentrate, coordinate, and comprehend information and to evaluate learning.

Significance

The ability to use critical thinking skills in is crucial in order for citizens to make active contributions to society (LaVenia & Pineau, 2010). Citizens are called upon to make decisions in data analysis using rational numbers and problem solving skills from sources including bank statements and research or marketing data. LaVenia and Pineau (2010) noted that many occupations require and rely on mathematics critical thinking skills to compete in a progressively changing work arena. Today's learners require a range of mathematics instructional strategies to be able to secure a comfortable position with employers in the community. Low levels of mathematics skills may also contribute to elevated unemployment levels, heightened prospect of imprisonment, and lower wages during an individual's lifetime (Gifford, Evans, Berlin & Bai, 2011).

If students are not educated in the mathematics instructional strategies needed to master complex mathematics problems, their grasp of the world may be restricted. Ozgen and Bindaka (2011) suggested that as students begin to develop better problem solving skills when working with more complex mathematical problems, they build mathematics self-efficacy which makes learning new mathematics concepts a positive experience.

Guiding/Research Question

The problem in this study is related to low test scores in state mathematics assessments. These scores suggest that teachers need to select and use appropriate instructional mathematics practices that help all students master abstract mathematics concepts. The difficulty for teachers is the selection and use of the most appropriate instructional mathematics practice that aligns with the concepts taught. Help choosing the most appropriate instructional mathematics practices could be a key to solving this problem.

The problem leads to the guiding question for this project study: In an urban middle school in Colorado, what are the mathematics teachers' perspectives on instructional practices for abstract mathematics concepts and content ? The local school district would benefit from clear evidence of instructional practices that lead to successful outcomes . Such instructional practices could be used to teach mathematics or practice concepts.

Review of the Literature

Database Search

In searching for literature on middle school students' mathematics achievement, I used the following databases: ProQuest, ERIC, Education Research Complete, Proquest Central, and The Teacher Reference Center. In the beginning of the search, I used *middle school mathematics* as a place to start. After locating some literature on learning deficiencies in middle school mathematics, I broadened the search and included mathematics instructional strategies in other middle school content areas. The following concepts were used : *low math achievement, middle school math, middle school math, math instructional strategies, mathematics instructional strategies, math achievement gaps, mathematics achievement gap, math learning theory, mathematics learning theory, predictors of math achievement, predictors of mathematics achievement, math learning* *theories*, *junior high math, junior high mathematics, primary learning theories, mathematics secondary learning theories, brain-based learning, brain-based teaching, brain-based learning strategies, strategic teaching, cognitive strategy, problem-solving strategies, innovative strategy, literacy strategies*, and *math strategies*.

Strategic Teaching in Mathematics

Some researchers reported that students in content areas, like mathematics, need to be taught following a process similar to strategic planning used in the business world (Graeff, 2010). Mathematics instruction could be taught to students in a way that accounts for various parts of the overall learning plan. Students can be active rather than passive beneficiaries of knowledge, and the learning event should go beyond what can be acquired just from a text book (Graeff, 2010).

Reasons for using strategies. Several reasons exist for using strategies or strategic teaching in mathematics instruction. Strategies are often active learning which can be motivational for students (Graeff, 2010). Strategic teaching and learning helps to move the brain from its comfort zone into a higher working capacity (Halakatti, 2010). Strategies in teaching and learning also help to meet different student learning styles (Freeman & Walsh, 2013).

Benefits and obstacles in strategic teaching. Graeff (2010) suggested benefits for strategic teaching. Strategic teaching is used to combine skills necessary for learning rather than teaching skills in isolation. Combining skills in strategic teaching allows teachers to teach more content and skills, and allows students to make connections among the skills learned. When students are taught using strategic instruction, students learn more, retain what is learned longer, and apply their knowledge in new situations.

As a second benefit of strategic teaching is the teacher-student relationship involved in using this delivery model. Students are empowered to be learn side by side with the teacher, which enables students to communicate what they understand and do not understand in a risk-free environment (Graeff, 2010). This working relationship may reduce anxiety in learning new concepts and content for the students, because the teacher is directly involved in interaction with students and what they learn. In traditional classrooms where lecture is the predominant method of instruction, instruction is only provided one-way from the teacher to the student. Lecture may be necessary to provide foundational content, but this method of delivery rarely allows for student-teacher interaction.

A third advantage of strategic teaching is the information the classroom teacher can access about student learning (Graeff, 2010). When strategic teaching is applied, a teacher can address any student misunderstandings immediately rather than leaving students frustrated if they have not grasped the concepts and skills taught for specific mathematics content. This immediacy in addressing problems in learning the content lessens the chance of reteaching concepts and skills, thus, increasing the amount of content and skills to be taught. Ultimately, strategic teaching keeps classroom learning from being redundant and tied to the learning in textbooks. When planning mathematics instruction, all of these benefits should be considered in the teaching and learning process.

Kay and Swanson (2011) noted some of the following obstacles that can cause problems when introducing strategic teaching to teachers. These researchers identified teachers' beliefs or biases, lack of confidence, and lack of sufficient exposure to teaching strategies as the main obstacles to strategic teaching. Teachers might have beliefs or biases against some of the strategies. For example, teachers who revert to traditional teaching methods for mathematics based on how he or she learned this content when they were students in school. Some teachers might have a lack of confidence in their ability to implement teaching strategies due to minimal experience or training in strategic teaching. Pre-service teachers may have little exposure to some teaching strategies because their college and/or student teaching experiences did not include newer or innovative strategies. These issues should be considered when exploring strategic teaching in mathematics.

Best practices in teaching mathematics. Best practices in teaching mathematics may include cognitive strategies, problem-solving strategies, innovative strategies, strategies borrowed from literacy instruction, or strategies very specific to mathematics instruction (NCTM, 2000). The term *best practice* (research-based or scientifically-based), common in evidence based education, is used to describe what works in the classroom. Teachers are encouraged to use their professional wisdom to determine what works for their students in the content area.

Cognitive strategies may enhance mathematics achievement in students. Swanson (2014) studied application of cognitive strategies dependent upon the student's working memory capacity (WMC). These strategies can include helping students solve mathematics word problems using verbal, spatial, or verbal and spatial strategies. The results of the study showed that students with high WMC's fared well with the verbal and spatial strategies such as diagramming. Students with a low WMC did not do well with some of the cognitive strategies such as verbal (key word location), visual strategies (placing numbers into diagrams), and verbal and visual (diagramming numbers or combination of verbal and visual. Based on Swanson's (2014) study, it cannot be assumed that all students would benefit from cognitive teaching strategies in mathematics; however, cognitive strategies should be considered and teachers' discretion and professional judgment used should be applied.

Bayazit (2013) studied whether middle school students could successfully solve real life problems using problem-solving strategies that could include listing strategies, application of mathematics models, and drawing pictures. The students were unable to apply problem-solving strategies to the presented mathematics problems, and Byazit's (2013) findings suggested that teachers work on problem-solving strategies with students to reinforce their critical thinking skills. Problem-solving strategies should be considered essential to strategic mathematics instruction.

Innovative teaching strategies may also help raise student mathematics achievement. Sherer and Grunow (2011) studied effective strategies in development mathematics at the community college level. The study used a 90-day process or cycle to determine the program efficacy, allowing a quick determination on whether innovative mathematics strategies were helpful or worthy of time in the classroom. Innovative strategies should be investigated to determine if they are worthy of inserting into mathematics education (NCTM, 2000).

Some instructional strategies are appropriate for all content areas and could be applied specifically to mathematics instruction. Howe, Mundy, Kopczynski, and Cummins (2012) investigated teacher knowledge, use of, and recommendations regarding instructional strategies for literacy (e.g. brainstorming, graphic organizers, and vocabulary cards). The study results indicated that teachers with related graduate courses were more likely to apply these strategies and that more experienced teachers were more likely to use or recommend them to others. Although this study focused on teacher implementation and sharing of instructional strategies in literary courses, these same instructional strategies may be useful in a mathematics classroom as well.

Mathematics strategies can be used to engage students and to help them to become more interested in learning mathematics (Ludwig, 2014). Ludwig (2014) suggested several mathematics instructional strategies that can be used across all strands of mathematics. Structured learning, cooperative learning groups, teaching of vocabulary, using manipulatives, varying assessments, and mathematics journals are beneficial in learning, regardless of the mathematic content. All of these strategies should be considered when planning mathematics lessons to better prepare students and improve student achievement.

Conceptual Framework

The conceptual framework for this study is based on the quest for effective instructional mathematics practices in mathematics instruction. The best resource to use as a starting point in this research comes from the NCTM. *Principles and Standards for School Mathematics* is one of NCTM's publications that was created to guide policymaking related to the improvement of mathematics education (NCTM, 2000). Within this guide, six principles are examined that may assist in planning mathematics instructional methods, mathematics learning, and in the creation of top-quality mathematics programs (NCTM, 2000). These six principles include (NCTM, 2000): (a) equity, (b) curriculum, (c) teaching, (d) learning, (e) assessment, and (f) technology.

Equity principle. The first principle addressed is equity. Equity includes the themes of significant expectations and meaningful potentials for all learners (NCTM, 2000). This principle is based on the idea that one's potential to learn mathematics should not be lowered due to extenuating circumstances which could include language deficiencies, socioeconomic status, or disabilities. Instead, this principle advocates that additional resources be used to help all learners meet high mathematics learning expectations. One of the most important resources identified that can help with equity is to increase professional development for teachers to help them to better understand and accommodate mathematics instruction for various student needs (NCTM, 2000).

In alignment with the Equity Principle from the NCTM (2000), some research has been conducted to determine how high expectations in student learning has impacted student learning in mathematics. The results of this research could help with planning the best possible mathematics instruction for middle school students.

Research was conducted with students performing at a low level in mathematics to see if higher teacher expectations had an impact on the students' achievement

(Woolley, Strutchens, Gilbert, & Martin, 2010). The equity principle looks for high expectations in mathematics achievement from teachers with for all students regardless of learning issues, language deficiencies, or socioeconomic status (NCTM, 2000). Several factors were studied along with high teacher expectations in this study (Woolley et al., 2010). Many students performed better as a direct result of higher expectations, but for some students, higher expectations caused heightened anxiety, which lowered assessment scores. The researchers also suggested that students might need time to adapt to these heightened expectation, so it was recommended that further longitudinal studies should be conducted to see if the anxiety decreases as students get used to the idea (Woolley et al., 2010).

Williams (2010) studied nine minority high school students who succeeded in higher level mathematics classes despite obstacles. She discovered that there were several commonalities, and one of the most identified by the students was high expectations by mathematics teachers. One recommendation from this researcher was related to the environment of minority students who are successful in mathematics. In her research, it was determined that environmental factors helped the students to succeed and access to rigorous content and high expectations were part of this environment. She recommended that further research related to these areas would be beneficial to help future students experience success in high level high school mathematics classes (Williams, 2010).

Curriculum principle. The next principle is curriculum. The idea behind this theme relates to connecting the different strands of mathematics so that they are not taught discretely (NCTM, 2000). The mathematics concepts taught should be worthwhile or have purpose in everyday life, and these connections should be presented in mathematics instruction. Throughout the years, mathematics concepts should build upon prior mathematics knowledge and take students deeper in the level of sophistication and understanding of concepts (NCTM, 2000).

Kelly (2008) studied the effect of a mathematics intervention program on middle school student achievement that included the use of real-life learning experiences. The overall increase in mathematics achievement for the test group was not significant, but there was significant increase in three strands of mathematics based on the state test scores. The three mathematics strands with the highest impact from this intervention program included computation and estimation, statistics and probability, and patterns and relationships. Recommendations for future research included looking at more qualitative and quantitative research that would help to dig deeper into the impact of this type of mathematics intervention on the student’s understanding using tools other than just an achievement test (Kelly, 2008).

Nehme (2011) studied the impact of real life connections of matrices related to students’ engagement and motivation. The students were required to research real life application of matrices and to report their findings and interact on a blog created for the purpose. The students reported high engagement and motivation at the end of the activity for a concept that might not be one where students easily form a connection (Nehme, 2011). The idea of real life application of complex mathematics concepts is one that might engage students in all grade levels.

Teaching principle. Another principle shared is the teaching principle. This theme centers on the practice of sound teaching (NCTM, 2000). An important part of sound teaching is creating a thought-provoking yet compassionate teaching setting. Sound teaching also means that a teacher should continuously be seeking improvement in teaching practices related to mathematics (NCTM, 2000).

One recent study examined the success of developing leaders out of teachers with strong mathematics teaching practices. These teachers were used to mentor other mathematics teachers and lead learning communities which resulted in higher student achievement in mathematics (Vale et al., 2010). Recommendations from the researchers include delving further to determine what teaching practices lead to higher levels of student achievement in mathematics.

Gasser (2011) observed five keys to being able to teach mathematics successfully, and several correlated to sound teaching practice. One of the ideas was related to using problem-based instruction in learning activities. Another idea was creating a classroom climate where students feel comfort in taking risks. Creating fun in the mathematics learning environment is another idea that Gasser (2011) credited to help students have higher levels of mathematics achievement. These ideas could be explored further as effective instructional mathematics practices are analyzed so that they can be reproduced in many classrooms.

Learning principle. The learning principle follows the teaching principle. This principle is based on student learner’s developing deep and flexible understanding of mathematics concepts (NCTM, 2000). Teachers need to provide experiences that provide a deeper meaning and learning level for students through appealing activities and classroom communications (NCTM, 2000).

Delacruz (2011) studied the impact of games on student mastery of mathematics concepts. The study was conducted with control groups of fourth and fifth grade students. Attributes of the game including incentives for feedback seeking and detailed rules were examined to determine if this led to higher levels of understanding. The finding included the most growth in students with very low pretest scores who were provided with both detailed rules and feedback seeking incentives. The recommendations from Delacruz (2011) included including more mathematics games that have mechanisms for students to have more detailed rules and incentives for seeking feedback. Another recommendation was to look for the motivating factors in learning mathematics with well-planned games in future studies.

Xiong (2010) researched in a longitudinal study the causal relationship between mathematics instructional strategies and student achievement. The results of state achievement tests for students in Grades 2 through 6 was compared over 3 years after a new mathematics curriculum was introduced. The data showed varying levels of improvements in student achievement from year to year. The new mathematics program emphasized teaching in an organized system using strategies that included all five senses. Xiong (2010) recommended that future studies should be conducted to study causal relationships between mathematics strategies and student achievement.

Schmitz and Perels (2011) studied how self-regulated learning affected mathematics achievement with eighth grade students. The students used a diary to selfmonitor mathematics learning throughout a unit of study. The students' learning was compared to a group of students who completed the same unit without the self-monitoring. The group who used the diary during the unit showed greater growth than the control group based on pre and post assessment data. Schmitz and Perels (2011) recommended that this and similar types of self-regulatory strategies should be applied in mathematics and other subjects to provide students with a learning advantage because of the positive results from this study.

Assessment principle. Assessment is something that should increase learning. Using assessment as an instrument is one of the best way to make educational decisions (NCTM, 2000).

Shaffer (2011) conducted a study to determine if differentiated instruction made a different in middle school mathematics achievement scores. The differentiation was based on using pre assessment and formative assessment to influence instructional decisions. The research results showed a significant increase in mathematics achievement scores as a result of differentiated instruction. Shaffer (2011) recommended that further studies could be done to study the implementation of differentiated instructional strategies in mathematics and other content areas.

Jackson (2012) studied the experiences of teachers in using data-driven instruction to help with instructional decisions in middle school mathematics instruction. The findings were that these teachers with different years of experience and education levels lacked the training or understanding of how to use data to make instructional decisions in their mathematics classrooms. Jackson (2012) recommended that future studies could be conducted in administrator perceptions of teacher data use and in the effects of data driven instruction on mathematics achievement.

Technology principle. Technology enriches student learning in all mathematics strands, algebra, geometry, measurement, data analysis, and probability. There are applications and programs that can help students on an IEP for mathematics or students who need more visual strategies for learning. Technology, itself, should not be the mathematics teacher. Teachers should use it in efficient ways to support teaching and learning. In addition, decisions about teaching mathematics are partly determined by current technology (NCTM, 2000).

Lewis (2011) conducted research related to the effect of computer assisted instruction (CAI) on mathematics achievement with a group of fourth grade students. In the study, there was a control group who received traditional mathematics instruction only, while the test group was provided with the same traditional mathematics instruction along with CAI technology integration in lesson. The test group scored significantly higher on the post assessments provided to both groups. Lewis (2011) recommended that CAI should be researched in other grade levels to decide if the results could be generalized within higher grade level mathematics achievement levels.

Allison (2012) researched the use of Computer Performance System (CPS), also known as clickers, along with peer instruction (PI), as an additional learning strategy, in relation to student mathematics scores. The idea was to determine whether technology along with sound instructional strategy could raise eighth grade mathematics achievement. The results showed that technology like CPS along with sound instructional strategies like PI raised mathematics achievement significantly. Allison (2012) recommended that CPS should be a focus in future research combined with other grounded mathematics strategies to see if this combination of technology and instructional practice has impact on student achievement.

Implications

Based on feedback from a panel of middle school mathematics teachers and a review of the literature, through an exploratory study using the modified Delphi method, I explored middle school mathematics teachers' perspectives regarding instructional mathematics practices for abstract mathematics concepts and content taught in an urban middle school in Colorado. After input was collected and analyzed, it was possible to create a guide that would support any administrator or teachers seeking improved mathematics scores. Possible projects could be a curriculum or instructional guide that provides instructional mathematics practices that align with NCTM middle school mathematics content standards or resources and professional development for new or struggling mathematics teachers. The impact of these data could be powerful for any teacher working with struggling mathematics students as they would indicate instructional mathematics practices of middle school mathematics teachers based on the NCTM middle school mathematics content standard.

An essential element to this project study's usefulness is that the actual project be presented with effective instructional mathematics practices from a practitioner's perspective in a comprehensible and clear-cut format. If stringent observance of these recommendations are followed, teachers may be willing to assimilate these instructional mathematics practices into their everyday lesson plans. As an outcome, student grasp of complex mathematics concepts may strengthen confidence and lower the feelings of exasperation by the student and teacher.

Summary

Some middle school students at a Colorado urban school district have had problems mastering mathematics concepts, as shown from figures obtained from state standardized tests. The guiding research question for this project study was created to uncover what instructional mathematics practices should be inserted to the everyday practice of middle school mathematics teachers in a Colorado urban school district to improve student achievement in this content area as exhibited on the outcomes of annual state standardized tests. This project study was aimed at affording middle school mathematics teachers with a pool of instructional mathematics practices in a professional development training plan. When used with instructional mathematics practices regularly implemented in the mathematics classroom, this resource guide could be used to boost student achievement of middle school mathematics concepts.

Section 2: The Methodology

Introduction

The purpose of this study was to improve classroom instruction by using a modified Delphi method to exploring the perspectives of an expert panel of middle school mathematics teachers on instructional mathematics practices that draw on theories that are foundational to best practices in mathematics. In this section, the following topics are covered: the modified Delphi method and rationale, the sample and setting for the study, the data collection and analysis techniques, measures for protecting participant rights, and the role of the researcher in this process.

Research Design

The Delphi method, which originated at the RAND Corporation (Dalkey, 1969), is a method of collecting and synthesizing the opinions of a panel of experts on a topic in order to make decisions about policy or practice; it can be used across a wide range of fields (Clark, 2006). In general, in a Delphi study a series of surveys is designed to generate ideas or to synthesize opinions about a topic. Exploratory research in emerging areas is an appropriate place to conduct a Delphi study (Päivärinta, Pekkola, & Moe, 2011). This method is also appropriate in cases where the overarching problem might benefit from the insights of experts (Hsu & Sandford, 2007). These surveys are administered to experts, often dispersed over a wide geographical area, in three or more rounds of data collection. This method has been used in a range of educational settings to gather stakeholder beliefs about instruction and educational policy (Franklin & Hart, 2006; Mahmood, Iqbal, & Saeed, 2009; Williams, Boone, & Kingsley, 2004). Typically, the first round of data collection consists of open-ended questions and qualitative data (Williams et al., 2004), followed in subsequent rounds by quantitative or both quantitative and qualitative question types. After each round, the responses are analyzed and summarized; a feedback survey is developed for the same respondent group. In this second survey, respondents are asked to rate the responses from the group given in the first round using a Likert-type scale(Hsu & Sandford, 2007). A final round is often the chance for the experts to comment on opinions from previous rounds that deviate from the norm (Hsu & Sandford, 2007).

In this case, the modified Delphi method was used to obtain the opinions of experts on the types of instructional practices might increase student mastery of middle school mathematics concepts. The results from the research were critical to selecting a project for this study. The participants a middle school mathematics teachers who had taught adolescent learners for at least 5 years, who held an advanced degree in education, and who had taught mathematics to adolescent learners for at least 3 years. Their responses, which were collected and analyzed using both quantitative and qualitative techniques, were used to determine what instructional mathematics practices would be most helpful to these students.

Data Collection Strategy

This Delphi study may be considered a mixed method sequential exploratory study because the data were collected in three rounds (based on the surveys) and that the questionnaires consisted of quantitative and open-ended questions. The first round survey was used to collect open-ended responses from the middle school mathematics teacher panel. Subsequent surveys contained a combination of numeric and open-ended questions that will be created based on the first round results. This method was exploratory because the research process itself created opportunities to learn what areas should be explored further for this study research.

In a sequential exploratory mixed-methods study, data are collected in rounds using qualitative and then quantitative methods, and the analysis is investigated and analyzed for qualitative exploration (Creswell, 2013). In exploratory mixed methods, the qualitative data are collected and analyzed first. The information in this study was analyzed using content analysis (Stemler, 2001), and the results from it were used to create the numeric and open-ended questions for subsequent surveys. Dalkey (1969), the pioneer of modern day Delphi research methods, described this mixed methods Delphi process as “conducting the exercise in sequence of rounds between which a summary of results of the previous round are communicated to the participants” (p. 16). The three rounds of data collection that comprise this particular modified Delphi study are described in the next section.

Multiple Forms of Data Collection and Analysis

In the first modified Delphi data collection round, I collected qualitative data by asking the participants to respond to a series of open-ended internet survey questions in which they described instructional mathematics practices that can be used in the middle school mathematics classroom to teach the different NCTM middle school content standards. The participants were middle school mathematics teachers who meet inclusion criteria of at least 5 years teaching adolescent learners, an advanced degree in education, and at least 3 years teaching mathematics to adolescent learners. These open-ended responses were analyzed using qualitative content analysis to shape the creation of the mixed-question type surveys to be use in the second and third rounds. Surveys administered in the second and third rounds asked participants to rank the themes that emerged during the first survey and to explain why the participants believed these instructional mathematics practices should be ranked in this order.

The internet survey tool, Survey Monkey, was used to collect the survey responses. The first survey (see Appendix D) asked the participants to identify instructional mathematics practices and scenarios that might help students solve problems similar to the mathematics problems listed that match each of the mathematics strands in middle school mathematics. The participants were asked to provide examples and other details to help understand how the instructional mathematics practices might be used by students solving these types of problems. These instructional mathematics practices can later be analyzed with the goal of deciding how to implement them in curricula to improve student understanding of middle school concepts. Participant responses were analyzed using content analysis (Stemler, 1990). Instructional mathematics practices/scenarios corresponding to each question on the first round survey were summarized and similar responses were combined.

The second modified Delphi round (see Appendix E) consisted of a combination of closed- and open-ended questions based on the results of the first round’s results. After analyzing the list of instructional mathematic practices generated by the middle school mathematics teachers panel in Round 1 of the data collection, a second set of questions was presented again in an internet survey. A summary of the instructional mathematics practices was listed that were collected from the first round, and the panel rated their opinion of each instructional mathematics practices' effectiveness in relation to its possible use in seventh grade mathematics instruction. Each instructional mathematics practice was rated in a 1 through 5 point Likert system with 5 representing the highest rating. Then, in an open-ended follow-up question, the respondents were asked for reasons or details regarding why they felt this way about the instructional mathematics practice. Data from surveys that include close ended questions are quantitative (Creswell, 2013).

Finally, the quantitative internet survey administered in the third round (see Appendix F) was created based on the analysis of Round 2 quantitative and qualitative data. The Round 3 information presented to the participants was the compilation of the Round 2 findings in summary form. The purpose of the Round 3 data collection is for participants to arrive at a final consensus. In order to achieve final consensus, the Round 3 panel rated the instructional mathematics practices using a Likert scale of 1 to 5, where A five-point Likert scale was used, with scores ranging from 1 (*disagree very much*) to 5 (*agree very much*). The results were tracked for each question by finding the mean and then ranked from highest to lowest.

Justification for Delphi Method Research Design

This mixed methods study was based on the Delphi technique. A Delphi study is a method used to build a consensus about a concept or construct when one does not exist (Yousuf, 2007). It is characterized as a way for facilitating discussion between experts in the field of study. A Delphi study's purpose is to create consensus among knowledgeable individuals to address a complex problem (Yousuf, 2007). In the context of this study, a group of educators and researchers reached a consensus on the best instructional mathematics practices to use when teaching middle school mathematics so that the mathematics objectives can be attained. This study resulted in a collective prioritization of instructional mathematics practices that may be used to improve classroom instruction and student achievement on state standardized tests.

Since the Delphi process helps to develop consensus, it allows for participation in the research process by a panel of experts who assume the responsibility of making judgments about the best responses to the problem. While other mixed methods survey techniques could have been used to collect expert opinions about the most effective instructional mathematics practices, the Delphi method includes the expert participants in the judgment of those responses. Another advantage of the Delphi method over other qualitative research design methods is the anonymity of the participants with each other. If the panel were to meet face-to-face, the interpersonal dynamics would differ from those in an anonymous format. The Delphi method can provide results using more strategic information than other research methods since the feedback is controlled. This method allows for less bias due to the fact that all participants' opinions are presented without influence of the other participants (Hsu & Sandford, 2007). Finally, proponents of the Delphi method "recognize human judgment as a legitimate and useful input in generating forecasts and therefore believe that the use of experts, carefully selected, can lead to reliable and valid results" (Olds, Streveler, Miller, & Nelson, 2003, p. 2). The collective judgments of the panel are used to arrive at consensus which can lead to further research and/or help to make changes to policy or processes.

The Delphi method is also useful because it avoids bias that can occur when a group of experts meets face-to-face by taking out the communal connections that can change the way opinions are formed (Yousuf, 2007). The Rand report suggested that the anonymous feature of Delphi method makes the results more accurate (Dalkey, 1969). As a result of the Delphi method, this study was organized to show prioritization of instructional mathematics practices following an unprejudiced process.

The exploratory Delphi methodology provides several rounds that include mixed type survey questions. This methodology was chosen over a strictly qualitative or quantitative methodology. First, the qualitative input provides a way to solicit different ideas. The quantitative input using the Likert scale helps to order the ideas from most effective to least effective. The combination of qualitative and quantitative rounds in Delphi help to develop a consensus based on the ideas of the entire panel of experts. It also gives the expert participants more opportunity for fully describing their opinions on the types of instructional mathematics practices needed in particular scenarios. This explanation happens when a member of a panel either chooses on the low end, a 1, or on the high end, a 5, on the Likert scale when rating an instructional mathematics practice. At that point, the expert is asked to provide more information to explain the rating.

This method works well when data on a given topic are not documented or existing due to the difficulty of gathering experts together to work on a consensus on the topic (Yousuf, 2007). Yousuf (2007) stated that the Delphi method is “useful where the opinions and judgments of experts are needed, but time, distance, and other factors make it unlikely or impossible for the panel to work together in the same physical location" (p. 80). Bringing the opinions of the experts together in an exploratory Delphi study help to create a consensus of ideas that might not have been documented due to the constraints listed.

Integration of Research Methods

The integration of both qualitative and quantitative methods was evident in the three rounds of data collection, interpretation, and analysis. This modified Delphi method incorporates three rounds within the process. The first stage or round used qualitative data collection methods in an internet survey format. The internet survey included mathematics problems related to each strand of mathematics taught in middle school. The middle school mathematics teacher panel was asked to provide instructional mathematics practices that would help students learn how to solve the different problems. The data/ instructional mathematics practices collected were listed under each scenario and presented to the panel again as part of Round 2. If instructional mathematics practices collected from the panel were similar, they were not listed multiple times under a single scenario. For example, if one middle school mathematics teacher suggested an instructional mathematics practice of using real life applications in mathematics instruction, and another teacher from the panel suggest using authentic learning situations for scenario one, these were combined into one instructional mathematics practice.

In Stage 2, the middle school mathematics teacher panel judged the list of instructional mathematics practices collected in Round 1 for effectiveness in mathematics instruction for the specific scenarios in a new internet survey. The panel rated each instructional mathematics practice on the internet survey using a five-point Likert scale was used, with scores ranging from 1 (*disagree very much*) to 5 (*agree very much*). The ratings provided quantitative data. Then, the panel was asked for follow-up feedback with explanations for ratings. The follow-up feedback provided additional qualitative feedback. The data for each instructional mathematics practice collected was descriptively analyzed including frequencies, means, medians, and modes. Panel justifications were included for ratings of each instructional mathematics practice. All of the data from Round 2 was organized into a summary report which was presented in an email to the middle school mathematics teacher panel for Round 3. Creswell (2013) stated that quantitative methods include statistical analysis which can be in the form of an average. The qualitative feedback data were interpreted by the panel later in Round 3.

Finally, Round 3 included only quantitative data collection, interpretation, and analysis. The middle school mathematics teacher panel was presented the summary report from Round 2, and using this information, they rated the instructional mathematics practices one more time on a Likert scale. No qualitative feedback was collected in this stage. Each instructional mathematics practice was analyzed based on the mean for each instructional mathematics practice. The instructional mathematics practices were prioritized based on the quantitative analysis of this average and rank ordered from highest to lowest based on mean scores. These data were used to inform the final group consensus of the instructional mathematics practices.

Setting and Sample

The setting for the project was Colorado urban school district. The demographics in this district included 33% English Llanguage learners, 38% speaking Spanish as first language, and 72.5% qualifying for free or reduced lunch (DPS, 2013).

The sample for this research study included a middle school mathematics panel with at least 5 years of experience teaching, an advanced degree or higher in an education-related area, and at least 3 years teaching mathematics to adolescents. These education specialists included mathematics teachers and/or administrators with mathematics expertise. Some members of the middle school mathematics panel were also instructors at universities. The names of the participants were obtained from administrators. These candidates were sent an invitation via email that explained the study and asked them to respond if they were interested in participating (see Appendix B). Included in the email invitation was a consent form which participants were asked to return if they agreed to participate in the project study.

The total sample solicited for participation was 15-20 educators who met the eligibility criteria set forth in this section. As Hsu and Sandford wrote (2007), "Delphi subjects should be highly trained and competent within the specialized area of knowledge related to the target issue" (p. 3). Although Grisham (2009) noted that a minimum of 15 participants are necessary to conduct a valid Delphi study, Hsu and Sanford (2007) emphasized that there has not been an agreement on the ideal number of experts that should be surveyed in a Delphi study.

The sampling method used to choose the population was based on purposeful selection due to the nature of Delphi methodology. If more than 20 participants met the minimum qualifications, then random selection would have been used. The candidates would have been placed in a jar, and 20 names would have been selected Creswell (2013) indicated that purposeful research is common to qualitative research because this type of selection determined participants who have extensive knowledge of the problem and research question. Purposeful sampling was used to identify study participants for this research study (Neuman, 2003). Because the study's intent was to identify successful instructional mathematics practices from a middle school mathematics teacher panel, using confirming or disconfirming sampling was a purposeful instructional mathematics practice that could be used to test or explore further studies (Creswell, 2013). The sample invited to participate needed to have knowledge based on experience in teaching mathematics. Upon initial selection to participate, a selection letter was sent to each participant (see Appendix C).

Sequential Data Collection Strategy

In this section, I discuss the data collection sequences, including both qualitative and quantitative sequences.

Qualitative Sequence

Gaining access to participants. Potential teachers for the middle school mathematics teacher panel were solicited from educational communities with members meeting the panel criteria. The panel also included teachers who were instructors at colleges. The middle school mathematics teachers for the panel were solicited by contacting the administrator at the school district or dean or department head at the college. Candidates received an emailed description of the study and an invitation to participate. The email included an introductory paragraph explaining the purpose of the study and their role should they choose to participate in it. Additional information regarding the study was provided to the middle school mathematics teacher panel upon request via email or personal phone call.

Name/type of instrument and number of rounds. The instrument used for the qualitative sequence in Round 1 was a questionnaire containing a question for each of the mathematics strands (see Appendix D). These questions requested participants to list instructional best practices that might be useful for students to master and comprehend mathematics concepts. The instrument used for Round 2 was a 2-part questionnaire used to collect both quantitative and qualitative data as the respondents were provided pre choices and then justify these selections with personal commentary (see Appendix E). The instrument used for Round 3 was a strictly quantitative questionnaire that gathered a final rating for each of the instructional best practice from each teacher on the panel (see Appendix F).

Researcher/participant relationship. I developed a working relationship with the panel through regular email and/or phone contact. In this communication, I shared timelines, provided directions for each round of data collection, and answered questions.

Data triangulation. Data triangulation is not built into Delphi methodology because each round of data collection is separate (Hsu & Sandford, 2007). Each round was analyzed and a new data collection tool was created based on the previous round of data. This process further narrowed the focus on best instructional mathematics practices to use in mathematics instruction. All of the analysis was completed within the current round of data.

Role of the researcher. I was responsible for data collection and data analysis for each round of the data collection. I have been a mathematics teacher at either a high school or college for over 17 years; I have taught full time in a local high school and adjunct part time at two different colleges. I have been with my current full time employer for 2.5 years and my colleges for 6 years. Some of the participating middle school mathematics teachers were current or previous colleagues either from a school district or university where I have worked. The teachers on the panel, however, were not subordinates, in my reporting line, or subject to my authority. Therefore, my relationship with the participants did not affect data collection. The only connections to participants was through professional working relationships at the school district or university where we might both be employed. I encompass a few biases/experiences to my role as the researcher. These biases included experience and training in methodologies in multiple intelligences and brain-based learning theories. My experiences with applying these learning theories could have affected my perspective when evaluating data.

Quantitative Sequence

Name/type of instrument and number of rounds. The instrument used for the quantitative sequence was a questionnaire based on the information collected during the Round 1 and 2 of the modified Delphi process. The I nstructional best practices collected from Round 1 were rated using A five-point Likert scale was used, with scores ranging from 1 (*disagree very much*) to 5 (*agree very much*).The participants were deciding whether they agreed\ that the instructional best practice selected is one that would help the students to master each mathematics concept according to the NCTM middle school mathematics content standards. Qualitative data were presented in a summary report to the participants, which shows the explanations provided by the middle school mathematics teacher panel for rating choices. The panel rated the same list of instructional best practices one last time in Round 3 using the same Likert scale as in Round 2.

Concept measured by instrument. The instrument in Rounds 2 and 3 listed all of the instructional best practices collected from Round 1. Each participant rated each instructional best practice with the provided Likert scale based on its effectiveness in teaching the focus concept.

How ratings are calculated. During Rounds 2 and 3, each instructional best practice collected during Round 1 was presented to the middle school mathematics teacher panel so its effectiveness could be evaluated using a five-point Likert scale with scores ranging from 1 (*disagree very much*) to 5 (*agree very much*). The mean and mode for each instructional best practice were calculated. The data were used to analyze which instructional best practices the panel deemed effective for specific mathematics concepts. The instructional best practices were then rank-ordered based on the panel's opinions.

Processes for assessment of reliability and content validity of the instrument(s). The quantitative instruments were checked for reliability and content validity in a few ways. Some of the methods for this included field testing and member checks. Field testing includes giving the survey to others outside of the study to determine if the questions make sense and are asking for the information desired. Member checking includes checking with participants to be sure that the any possible interpretations are accurate (Creswell, 2013).

Data Analysis and Validity

Validity and reliability for both the qualitative and quantitative processes are critical components of a research study. When considering quantitative data, validity involves looking for exactitude in results using processes designed for this purpose (Creswell, 2013; Cone & Foster, 2006). This process enables others to apply findings from a study knowing that the findings came from an accurate research process. Quantitative reliability refers to the ability to use results from the instrument to make informative suppositions (Creswell, 2013). Reliability is not the same concept as validity, and it refers to the process of checking the "consistency of responses" (Creswell, 2013, p. 190). Using methods to ensure reliability and validity ensure that results from a study are viewed as trustworthy. Trustworthiness is the qualitative equivalent of validity and involves credibility, transferability, dependability, and confirmability.

Credibility

When analyzing data collected in this study, credibility is the relative confidence in the truth of the findings. Credibility was achieved by using the following procedures. Credibility was addressed is through member checks (Cohen & Crabtree, 2006) that were employed when the data are sorted from the first round was presented to the middle school mathematics teacher panel. This process occurs when participants are asked to check for correctness when information collected has been analyzed and restated in another way. Most information or collected data were presented *as is*; however, if instructional mathematics practices were very similar, they were combined into a single instructional mathematics practice to avoid repetition. The sample questions used in the survey for the first round represented concepts found in each strand of middle school mathematics. The panel’s opinions were solicited as to whether they feel the categorization of their Round 1 qualitative feedback was accurate. If the members of the panel are in consensus that there is a problem with the combining of data, their input was employed to make changes in the summary. Input from the panel was submitted to me on an individual basis.

Qualitative Validity

Validity issues in research originated from the researcher and/or middle school mathematics teacher panel showing bias in relation to the topic (Creswell, 2013). In qualitative research this issue is referred to as *confirmability*. To provide confirmability, I allowed the panel to provide feedback based on the research topic without offering my opinion or giving advice so that I did not influence the panel’s feedback in any way. The panel member’s comments remained anonymous.

Quantitative Validity

Content validity involves being able to make consequential conclusions from scores on the questionnaires (Creswell, 2013). Content validity was checked in this study to determine whether questions on the survey accurately measure the content that was intended to be measured. Each survey was field tested with 2 to 3 of the middle school mathematics teacher panel to ensure content validity. The panel was asked to give feedback as to whether each question on the survey measures the intended content. Feedback from the panel was used to make changes to survey questions throughout the process.

Sample size can also be a validity issue in regards to quantitative validity (Creswell, 2013). The number of experts should be a valid sample size which was previously identified as in the range of 15 to 20 participants in a Delphi study (Grisham, 2009; Hsu & Sandford, 2007). I contacted as many qualified middle school mathematics teachers in this field as possible based on the criteria described earlier in this section and randomly selected members to participate in the panel.

Reliability

Creswell (2013) articulated that qualitative reliability can be observed in different processes of research including transcription. Transcription issues could occur when categorizing the qualitative feedback from Round 1. The middle school mathematics teacher panel was asked to give input in the process to ensure they agreed with the list of summaries collect from Round 1 before the Round 2 rating instrument is created. Also, I included well documented information concerning the procedure used to transcribe this Round 1 feedback into a list of instructional mathematics practices. Creswell (2013) indicated that well documented qualitative procedures are crucial to reliability within a study. Coding was carefully completed to protect the identity of the various member of the panel. Each teacher was assigned a letter to identify his or her responses rather than using names.

Transferability

Generalizability occurs when other researchers try to generalize or replicate results from this study to another similar study (Creswell, 2013). The instructional mathematics practices chosen by the experts might be changed based on future research, but the modified Delphi method processes followed in this study could be used to research similar problems with mastery of difficult concepts in mathematics and other content areas.

Confirmability

Using the validation techniques discussed above, both the quantitative and qualitative data collected in this study using the modified Delphi method were valid and trustworthy. “Proponents of the Delphi method recognize human judgment as a legitimate and useful input in generating forecasts and therefore believe that the use of experts, carefully selected, can lead to reliable and valid results” (Olds et al., 2003, p. 2). Because Delphi has been recommended when creating educational policy (Olds et al., 2003), the solicitation of the experts’ opinions on finding the most effective instructional mathematics practices used for middle school concepts was a valid and trustworthy process.

Assumptions, Limitations, Scope, and Delimitations

In any study, the assumptions, limitations, scope and delimitations need to be acknowledged.

Assumptions

In this study, the following assumptions were made. Consistent with the constructs of the modified Delphi methodology used for this study, the first assumption was that using a team of middle school mathematics teachers as participants in the study was the best way to explore effective instructional mathematics practices because these panel members are best equipped to explore this subject area. The second assumption was that all participants in this study answered all questions accurately and honestly. The third assumption that the middle school mathematics teachers used for this study actively participated in this study from the beginning of data collection through the end of data collection.

Limitations

The study was subject to the following three limitations :

1 Some of the participants worked together at the same school or in the same district.If participants talked to one another about the questions before providing their own responses, the value of their input could be reduced. At the beginning of each round of data collection, participants were told not to talk to other participants about their responses, either before or after responding.

2 A second potential limitation was that a participant or participants may wish to withdraw from the study for personal or professional reasons and may have done so either by voicing this choice or by no longer providing responses to the research instrument questions. To mitigate this potential limitation, the

study sought to recruit enough middle school mathematics teachers to act as participants. As part of the recruitment process, the expected timeframe for participation was provided along with the importance and expectation of each participant completing the study.

3 A third limitation of the study was the research method. Using the modified Delphi method is a limitation because it does not allow the researcher to use a larger group. The method also locks the researcher into a method when there could be another methodology that might be a better choice.

Scope and Delimitations

The scope of this study included a single Colorado urban school district. The study was delimited to the middle school mathematics teachers who met the following criteria: (a) at least 5 years of experience with adolescent students, (b) a graduate degree in an education-related field, and (c) at least 3 years of experience teaching mathematics to adolescent learners

Using only information from this group may have excluded other perspectives. These outside resources, however, would not have met the criteria for the panel necessary for use of the Delphi method (Yousuf, 2007).

Protection of Participants' Rights

I secured permission to conduct the study from Walden's Institutional Review Board (Approval No. 05-21-14-0093230). If participants from school districts were solicited, I contacted their school district administrator. If participants were solicited from universities, their university IRB process would need to have been followed. Data were not collected until IRB approval and participating institutions approval was granted; then the participants were supplied information including the steps they are expected to follow in the study.

The participants were notified first via an introductory email that contained a consent form. In the form, the participants were notified of the right to privacy and the right to choose to participate. The email also included information about the role and requirement for participants. The participant was invited to ask clarifying questions on a phone conversation and/or via email to help make the decision about whether they wanted to be a part of the study. If the participant decided to participate, they returned the signed consent form via email within a week. Participants were notified by email to confirm his or her role and to advise him or her of the next steps in the process. These steps helped to avoid ethical issues in the process.

The anonymity factor of the modified Delphi process also protected participants. Since, the questionnaires were completed via Survey Monkey™, the participants did not meet face-to-face. Participants' identities remained confidential and were not be shared with anyone involved in this study. A unique coding identifier was put into place to ensure participant confidentiality. Each participant was assigned an alphanumeric code such as A01, B02, and so on. No harm came to the participants as a result of this research because their identities were protected. The data will be stored in my home safe for a period of 5 years after which it will be destroyed.

Results

The following section details the data collection results for the three rounds of this modified Delphi study. Data were collected from middle school mathematics teachers to answer the following research question: What are middle school mathematics teachers' perspectives of instructional mathematics practices for abstract mathematics concepts and content taught in an urban middle school in Colorado? After soliciting participation from professional mathematics educator resources, seven middle school mathematics teachers were willing and eligible to participate in this study. Table 1 details the criteria and participant responses to the qualifying questions prior to participation in the study.

Table 1

Criteria for Participants in Project Study

Participation Criteria	Yes	No
Teaching adolescent learners, $\geq$ 5 years	7	0
Earned advanced degree in education, $\geq$ Masters	7	0
Teaching mathematics to adolescent learners , $\geq$ 3 years	7	0
Total Eligible Participants	7	0

Each of these middle school mathematics teachers participated in all three modified Delphi rounds of data collection; each round provided opportunity to gather data to determine perspectives on appropriate instructional mathematics practices for middle school students. Teachers provided responses to open ended, Likert scaled, and rank-ordered questions via an electronic Survey Monkey link. The responses to the Round 1 Survey were compiled to create the Round 2 Survey. The Round 2 Survey also provided the foundation for the Round 3 Survey. The findings for Rounds 1, 2, and 3, including sample questions from the survey instruments, are presented sequentially in order to answer the research question.

Round 1: Initial Modified Delphi Round

In Round 1 of the data collection, seven middle school mathematics teachers were asked to provide recommended instructional mathematics practices for helping middle school students meet the NCTM middle school mathematics content standards. These standards include (a) numbers and operations, (b) algebra, (c) geometry, (d) measurement, and (e) data analysis and probability. The district and school mathematics objectives for common core standards adopted by the state of Colorado are aligned with these five NCTM middle school mathematics content standards. The Round 1 Survey includes the five NCTM middle school mathematics content standards, and a corresponding sample mathematics problem. Panel members responded to four questions designed to elicit effective instructional mathematics practices for teaching the sample problem. The four questions listed for each content standard/sample problem are listed below.

- Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.
- Please share exemplar or relevant problem/contexts.

- Which instructional strategies would you identify as most helpful from your own experience.
- Share your rationale about why/how these strategies work.

Numbers and Operations Content Standard. The first item for the panel was focused on the Numbers and Operations NCTM middle school mathematics content standard. The sample problem related to this standard and given to the panel was "A car travels 140 miles on 10 gallons of fuel. How far can it go on a tankful of gas if the tank holds 15 gallons?" The panel was provided with the four bulleted questions listed in the description of Round 1 as question 1a, 1b, 1c, and 1d.

Table 2 displays the data collected from Round 1, Numbers and Operations Content Standard. The responses for each question were examined to locate instructional mathematics practices. The practices that were located are listed in the table (see Table 2) along with the corresponding question and the participant. Many times, multiple participants agreed upon the same practices. For example, five of the participants listed inquiry learning/student led instruction in their responses. The only instructional mathematics practices that were not suggested by multiple participants were using colors to help track steps or patterns and using different numbers to solve similar problems

Numbers and Operations Content Standard outcomes. Eleven instructional mathematics practices were identified in the panel's Round 1 responses. These practices included (a) real world application, (b) small group collaboration and discussion, (c) vocabulary, (d) template/model, (e) using colors to help track steps or patterns, (f) connections to similar concept strategies/scaffolding, (g) independent practice, (h) use different numbers to solve similar problems, (i) use graphic organizers, charts, and tables, (j) inquiry learning/student led instruction, and (k) pictures and visuals. All practices were identified by the entire panel: one practice was identified by five participants; one practice was identified by four participants; five practices were identified by three participants; two practices were identified by two participants; and two practices were identified by one participant.

The mathematics instructional practices that were the most frequently identified were inquiry learning/student led instruction and pictures and visuals. Both of these practices were mentioned in three of the questions for the Numbers and Operation Content Standard. Inquiry learning/student led instruction was mentioned by five participants while pictures and visuals were shared by four participants.

Three participants identified real world applications, small group collaboration and discussion, vocabulary, template/model and graphic organizers, charts, and tables as instructional practices useful for solving the Numbers and Operations sample problem. The practice mentioned in all questions was small group collaboration. Real world application, template/model, and graphic organizers, charts, tables were shared in two questions. Vocabulary was shared in just one question.

Other mathematics instructional practices in the responses included independent practice and connections to similar concept strategies/scaffolding. Each practice was shared by two participants. Independent practice was seen in two questions. Connections to similar concept strategies/scaffolding appeared in two questions.

The mathematics instructional practices mentioned by the least number of participants were colors to help track steps or patterns and use of different numbers to solve similar problems. Both of these practices were shared by only one participant. Colors to help track steps or patterns was seen in three questions. The use of different numbers to solve similar problems was shared in only one question.

Table 2

Round 1: Numbers and Operations Content Standard

Instructional Mathematics Practice	Question	Participants
Real world application	1a, 1d	1A, 5E, 7G
Small group collaboration and discussion	1a, 1b, 1c, 1d	4D, 5E, 7G
Vocabulary	1a	2B, 5E, 6F
Template/model	1a, 1c,	2B, 4D, 6F
Colors to help track steps or patterns	1a, 1c, 1d	2B
Connections to similar concept strategies/scaffolding	1a, 1b	1A, 2B
Independent practice	1b, 1c, 1d	4D, 6F
Use different numbers to solve similar problems	1a	3C
Graphic organizers, charts, tables	1a, 1c	3C, 4D, 7G
Inquiry learning/student led instruction	1a, 1b, 1d	1A, 3C, 4D, 6F,7G
Pictures and visuals	1a, 1c, 1d	4D, 5E, 6F, 7G

Numbers and Operations Content Standard rationale. In Round 1 of data collection, panel members were asked to provide rationales for the practices they identified for the numbers and operations content standard. Four panel members identified similar rationales for the practices they selected. Panels members 1A and 7G recommended real world application because this practice would be useful to assist students in understanding numbers and operations through inquiry learning in real life situations. Panel members 4D and 6F explained that vocabulary is important because terms students know can spark their interest.

Algebra Content Standard. The Algebra NCTM middle school mathematics content standard was the second item on the survey. The panel was presented with the following Algebra Content Standard sample problem: "ABC Phones sells monthly cell service for $0.50 per minute for the first 30 minutes but only $0.10 a minute for each minute after. Graph the rate of change for this plan." The panel was provided with the four bulleted questions listed in the description of Round 1 as question 2a, 2b, 2c, and 2d.

The data collected from Round 1, Algebra Content Standard, are included in Table 3. The responses for each question were examined to locate instructional mathematics practices. All practices were identified by the entire panel; two practices were identified by five participants; three practices were identified by three participants, one practice was identified by two participants; and two practices

Algebra Content Standard outcomes. Nine instructional mathematics practices were identified in the panel's Round 1 responses. These practices included (a) real world application, (b) small group collaboration and discussion, (c) vocabulary, (d) template/model, (e) connections to similar concept strategies/scaffolding, (f) independent practice, (g) use graphic organizers, charts, and tables, (h) inquiry learning/student led instruction, and (i) pictures and visuals. Some of these practices were identified by just one participant and others were identified by up to five participants each (see Table 3). None of the practices were mentioned by all seven of the participants in this round. The practices that were most frequently recommended were inquiry learning/student led instruction and pictures and visuals. Pictures and visuals were listed in four of the questions, and inquiry learning/student led instruction was listed in three of the questions. Both of these instructional mathematics practices were listed by five participants.

Several mathematics instructional practices were mentioned by three participants. The practices included (a) small group collaboration and discussion, (b) vocabulary, and (c) graphic organizers, charts and tables. All three practices were listed in two questions. A few practices were mentioned by two participants. The practices included real world applications and connections to similar concept strategies/scaffolding. Both of the practices appeared in two questions for each.

The mathematics instructional practices mentioned by the least number of participants were template/model and independent practice. Both of these strategies were shared by only one participant. Template/model was seen in 2 questions. Independent practice was shared in only one question.

Table 3

Round 1: Algebra Content Standard

Instructional Mathematics Practice	Question	Participants
Real world application	2b, 2d	1A, 3C
Small group collaboration and discussion	2a, 2c,	1A. 4D, 5E
Vocabulary	2a, 2b,	1A. 5E, 6F
Template/model	2c, 2d	3C
Connections to similar concept strategies/scaffolding	2a, 2b	2B. 7G
Independent practice	2d	4D
Graphic organizers/charts/tables	2a, 2c	2B, 3C, 4D
Inquiry learning/student led instruction	2a, 2b, 2c	1A, 4D, 5E, 6F, 7G
Pictures and visuals	2a, 2b, 2c, 2d	1A, 2B, 4D, 5E, 6F

Algebra Content Standard rationale. Panel members were asked to provide rationales for the practices they identified for the algebra content standard in Round 1 of data collection. Two panel members provided similar rationales for a mathematics practice they identified for this content standard. Panel members 1A and 2B use visuals and pictures to provide a graphic representation of equations to help students apply algebra to real world situations. These panel members also suggested that using visuals could help create a connection to the theories of number sense.

Geometry Content Standard. Geometry NCTM middle school mathematics content standard was the third item on the survey. The panel was presented with the following Algebra Content Standard sample problem: "List a triangle that is similar to the one with measurements 4, 4 and 7. Draw the new model and explain how you knew it was similar to the original." The panel was provided with the four bulleted questions listed in the description of Round 1 as question 3a, 3b, 3c, and 3d.

The data collected from Round 1, Geometry Content Standard, are included in Table 4. The responses for each question were examined to locate instructional mathematics practices. The practices that were located are listed along with the corresponding question and the participant (see Table 4). Four participants suggested the same practices such as inquiry learning/student led instruction. Three instructional practices, template model, using colors to help track steps or patterns, and independent practice, were not suggested by any participants but were listed under other content standards included.

Geometry Content Standard outcomes. Eight instructional mathematics practices were identified in the panel's Round 1 responses: (a) real world application, (b) use of technology, (c) small group collaboration and discussion, (d) vocabulary, (e) connections to similar concept strategies/scaffolding, (f) graphic organizers, charts, tables, (g) inquiry learning/student led instruction, and (h) pictures and visuals. All practices were identified by the entire panel; one practice was identified by four participants; three practices were identified by three participants; two participants were identified by two participants; and one practice was identified by one participant.

The practices that were rated as the most effective were inquiry learning/student led instruction and pictures and visuals Inquiry learning/student led instruction was mentioned by five participants in two of the questions for the Measurement Content Standard. Pictures and visuals were shared by four participants in three of the questions. Real world application, small group collaboration and discussion and connections to similar concept strategies/scaffolding were practices mentioned by four participants and all three of these practices were included in all four questions. Vocabulary and graphic organizers/charts/tables were shared by two of the participants. Vocabulary was included in two of the questions while graphic organizers/charts/tables was included in one of the questions. The mathematics instructional practice, technology, was mentioned by the least number of participants. This practice was shared by only one participant and appeared in just one of the questions.

Table 4

Round 1: Geometry Content Standard

Instructional Mathematics Practice	Question	Participants
Real world application	3a, 3b, 3c, 3d	1A, 2B, 3C
Use of technology	3a	2B
Small group collaboration and discussion	3a, 3b, 3c, 3d	4D, 6F, 7G
Vocabulary	3a	3C, 6F
Connections to similar concept strategies/scaffolding	3a, 3b, 3c, 3d	1A, 2B, 7G
Graphic organizers, charts, tables	3a, 3c	4D, 6F
Inquiry learning/student led instruction	3a, 3b	1A, 3C, 4D, 6F, 7G
Pictures and visuals	3a, 3b, 3c, 3d	2B, 3C, 4D, 6F

Geometry Content Standard rationale. In Round 1 of data collection, panel members were asked to provide rationales for the practices they identified for the geometry content standard. Four panel members provided similar rationales for practices they identified. Panel members 4D and 7G both recommended using the practice of small group collaboration and discussion to bolster other practices such as scaffolding and the use of graphic organizers. Panel members 3C and 6F both discussed the importance of having the students, not the teacher, draw pictures of the geometry concepts and problems they are working on as a way of developing and demonstrating an understanding through the use of visuals.

Some panel members described the teaching of geometry in a few ways. A few described it as a visual learning. Because of the visual focus, a few talked about drawing as a strategy for students to work through geometry problems.

Measurement Content Standard. The measurement NCTM middle school mathematics content standard was the fourth item on the survey. The panel was presented with the following Measurement Content Standard sample problem: “Scale factor: 1 inch = 300 miles. If the distance from Denver, CO to Salina, UT is 1.5 inches on the map, how far is the distance between the two cities in miles?” The panel was provided with the four bulleted questions listed in the description of Round 1 as question 4a, 4b, 4c, and 4d.

The data collected from Round 1, Measurement Content Standard, is included in Table 5. The responses for each question were examined to locate mathematics instructional practices (see Table 5). All practices were identified by the entire panel; three practices were identified by four participants; two practices were identified by four participants; and one practice was identified by one participant.

Measurement Content Standard outcomes. Nine instructional mathematics practices were identified in the panel’s Round 1 responses. These practices included (a) real world application, (b) use of technology, (c) small group collaboration and discussion, (d) template/model, (e) connections to similar concept strategies/scaffolding, (f) independent practice, (g) graphic organizers, charts, tables, (h) inquiry learning/student led instruction, and (i) pictures and visuals. Real world experiences, graphic organizers, charts, tables, inquiry learning/student led instruction, and pictures and visuals were most frequently recommended practices by the participants. Real world application was shared in all four questions. All of these practices were recommended by three participants. Graphic organizers, charts, tables were each included in three questions. Inquiry learning/student led instruction was mentioned in two of the questions.

Use of technology, small group collaboration and discussion, template/model, and connections to similar concept strategies/scaffolding were mentioned by two or fewer participants. The use of technology was shared in three questions. All of the other practices were shared in one question each. Independent practice was mentioned by just one participant in two of the questions.

Table 5

Round 1: Measurement Content Standard

Instructional Mathematics Practice	Question	Participants
Real world application	4a, 4b, 4c, 4d	1A, 2B, 6F
Use of technology	4a, 4c, 4d	2B, 4D
Small group collaboration and discussion	4d	3C, 7G
Template/model	4a	2B, 7G
Connections to similar concept strategies/scaffolding	4a	1A, 7G
Independent practice	4c, 4d	4D
Graphic organizers, charts, tables	4b, 4c, 4d	4D, 6F, 7G
Inquiry learning/student led instruction	4a, 4b	1A, 4D, 6F
Pictures and visuals	4a, 4c, 4d	3C, 4D, 6F

Measurement Content Standard rationale. Panel members were asked to provide rationales for the practices they identified for the measurement content standard in Round 1 of data collection. Three panel members provided similar rationales for two of the practices identified for this content standard. Panel members 2B and 6F suggested that the use of real world examples including itmes they are familiar with will help with this kind of problem. These panel emembers suggest using comparisons between small and large animals or the movie, *Honey I Shrunk the Kids* to help studnets understand measurement concepts and proportion. Panel members 3C and 6F recommended the use of visuals to help students gain an understanding of the concept of small to large, large to small, and similar ratios., because these visuals will help the students properly set up the problem, which is key to being able to understand and solve the problem.

Data Analysis and Probability Content Standard. The data analysis and probability NCTM middle school mathematics content standard was the fifth item on the survey. The panel was presented with the following Data Analysis and Probability Content Standard sample problem: “Collect data from newspaper weather/temperature charts about the temperatures in selected cities within a region of the United States. Calculate central measures and determine which city is warmest. Analyze the data to make conjectures about the warmest city and determine if different central measures yield different results.” The panel was provided with the four bulleted questions listed in the description of Round 1 as question 5a, 5b, 5c, and 5d.

The data collected from Round 1, Data Analysis and Probability Content Standard is included in Table 6. The responses for each question were examined to locate instructional mathematics practices (see Table 6).

Data Analysis and Probability Content Standard outcomes. Eleven instructional mathematics practices were identified in the panel’s Round 1 responses. These practices included (a) real world application, (b) use of technology, (c) small group collaboration and discussion, (d) vocabulary, (e) template/model, (f) connections to similar concept strategies, (g) independent practice, (h) use different numbers to solve similar problems, (i) graphic organizers, charts, tables, (j) inquiry learning/student led instruction, and (k) pictures and visuals. All practices were identified by the entire panel; one practice was identified by six participants; two practices were identifited by four participants; 1 practice was identified by three participants; two practices were identified by two participants; and five practices were identified by five participants.

The practice that was most frequently recommended was real life application. This practice was mentioned in all four of the questions in the Data Analysis and Probability Content Standard and was shared by six of the participants. Small group collaboration and discussion and inquiry learning/student led instruction were mentioned by four participants. Inquiry learning/student led instruction was shared in all four questions, and small group collaboration and discussion was mentioned in two questions. Graphic organizers, charts, and tables was shared by three participants was practice was in three questions. Template/model and independent practice were mentioned by two participants, and both of these practices were included in two questions each. The least number of participants included (a) use of technology, (b) vocabulary, (c) connection to similar concept strategy/scaffolding, (d) use different numbers to solve similar problems, in two questions, while the rest of these practices were shared only in one question each.

Table 6

Round 1: Data Analysis and Probability Content Standard

Instructional Mathematics Practice	Question	Participants
Real world application	5a, 5b, 5c, 5d	1A, 2B, 3C, 5E, 6F, 7G
Use of technology	5a, 5c	5E
Small group collaboration and discussion	5a, 5b	2B, 5E, 6F, 7G
Vocabulary	5b	6F
Template/model	5a, 5b	4D, 7G
Connections to similar concept strategies/scaffolding	5a	1A
Independent practice	5b, 5d	5E, 7G
Use different numbers to solve similar problems	5a	6F
Graphic organizers, charts, tables	5a, 5c, 5d	2B, 3C, 4D
Inquiry learning/student led instruction	5a, 5b, 5c, 5d	1A, 2B, 4D, 6F
Pictures and visuals	5a	4D

Data Analysis and Probability Content Standard rationale. In Round 1 of data collection, panel members were asked to provide rationale for the practices they identified for the data analysis and probability content standard. Four panel members provided similar rationales for two of the practices identified for this content area. Panel members 2B, 3C, 5E, and 6F recommended real world application. These panel members suggested that allowing students to perform real life data collection, especially if it is part of their every day lives instead of just within the classroom, motivates students to want to gain a better understanding of this challenging content standard. Panel members 2B and 3C recommended the practice of using graphic organizers, charts, and tables as this will help students to more easily organize their data during data collection and to make it easier to analyze.

Round 2: Second Modified Delphi Round

Each of the seven participants on the panel received a survey with the five content standards from Round 1. The instructional mathematics practices collected from the panel in Round 1 were listed under each question, and the panel was asked to rate each instructional mathematics practice's effectiveness using a Likert scale and provide a rationale for each instructional practice. A practice rated as a was judged to be not effective, a 2 meant minimally effective, a 3 was somewhat effective, a 4 was effective, and a 5 was very effective. Each content standard in Round 2 had 8 to 11 instructional mathematics practices that were identified in Round 1: (a) the Numbers and Operations Content Standard had 11 instructional mathematics practices, (b) the Algebra Content standard had 9 instructional mathematics practices, (c) the Geometry Content Standard had 8 s instructional mathematics practices, (d) the Measurement Content Standard had 9 instructional mathematics practices, and (e) the Data Analysis and Probability Content Standard had 11 instructional mathematics practices

Numbers and Operations Content Standard Quantitative outcomes. The data collected from Round 2, Number and Operatotions Content Standard is included in Table 7. The responses for each question were examined to locate trends and patterns regarding instructional mathematics practices (see Table 7).

In Round 2, for teaching numbers and operations, the panel rated demonstrate real world application as the most effective instructional mathematics practice (*m* = 4.14), also taking mean and mode into account. The panel also rated explore the vocabulary as the least effective instructional mathematics practice (*m* = 2.43) for teaching numbers and operations.

The most effective instructional mathematics practices for the Numbers and Operations Content Standard shared a common characteristic of having students make connections in their learning to their environment, previous learning, and to others through the demonstrate real life applications practice. Students connect numbers and operations content to students' prior knowledge and new knowledge through the connect learning to similar concepts practice. Students are provided a setting to share and connect the learning of numbers and operations content through interaction with one another via the use small group collaboration and discussion.

The least effective instructional mathematics practices for this content standard were instructional practices that did not require the students to interact as much with others, the environment, or to previous learning The least effective instructional mathematics practices included provide a template/model, use colors to help track steps or patterns, and explore the vocabulary. Although these practices may be effective instructional practices in learning, the panel did not rate these instructional mathematics practices as effective in numbers and operations instruction.

Table 7

Round 2: Numbers and Operations Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Demonstrate real world application	4.14	5	5
Connect learning to similar concepts (scaffolding)	4.29	4	4
Use small group collaboration and discussion	4.00	4	4
Provide examples (use different numbers to solve different problems)	3.86	4	4
Use graphic organizers, charts, and tables	3.29	4	4
Provide pictures and visuals	3.29	4	4
Work independently (practice alone)	3.29	3	2, 3, 4
Use inquiry learning (student-led instruction)	3.14	3	3
Provide a template/model	3.00	3	3
Use colors to help track steps or patterns	2.43	3	3
Explore the vocabulary	2.43	2	2

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Numbers and Operations Content Standard qualitative outcomes. Panel members were asked to provide a rationale for their rating of each practice in the Numbers and Operations Content Standard in Round 2 of data collection. A comment on the rationale for the rating of each practice was required before the panel member could proceed to the next practice. Rationales for the practices with a mean rating of 4.0 or above and below 3.0 are presented here.

Panel members, 2B and 4D, rated the practice of demonstrating real world application a 5 on the 1-5 Likert scale, but both panel members agreed that while the practice was helpful for buy in, students might still have problems applying to and solving individual problems without the use of other practices, too. Panel members, 2B and 5E, gave similar rationales for their rating of the practice of connecting learning to similar concepts (scaffolding), recommending that connecting the learning to prior knowledge makes it more real and easier to apply for the student. For the practice of using small group collaboration and discussion, panel members, 1A and 5E, suggested that this practice will allow students to use their social learning skills to develop higher thinking skills through group collaboration. Panel members, 1A and 4D, provided a low rating for the practice of using colors to help track steps or patterns, suggesting that this practice is too basic and would move students away from the larger concept. Panel members 3C, 6F, and 7G all rated the practice of using vocabulary low for numbers and operations, identifying that the practice might have some level of importance but would not help the students get to the right answers.

Algebra Content Standard quantitative outcomes. The data collected from Round 2, Algebra Content Standard is included in Table 8. The responses for each question were examined to locate trends and patterns regarding instructional mathematics practices (see Table 8).

In Round 2, for teaching algebra, the panel rated use graphics and visual organizers as the most effective instructional mathematics practice (*m* = 4.43). The most effective two instructional mathematics practices are ones that require students to use visual tools to help with learning, The most effective practice was graphics, visual organizers, and charts, and the second most effective practice was provide pictures and visuals.

The panel also rated explore the vocabulary as the least effective effective mathematics practice (*m* = 2.71) for teaching algebra. This practice could be helpful with algebra content; however, the panel did not rate it as being the most effective of the practices suggested for this content area.

The practices rated as the least effective for teaching algebra were (a) working independently and (b) exploring the vocabulary. Similarly, the least effective numbers and operations instructional mathematics practices was use colors to help track steps or patterns and explore the vocabulary. These mathematics instructional practices allow students to learn without the support of a small group or partner. These practices allow the student to work indepenedently

Table 8

Round 2: Algebra Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Use graphic organizers, charts, and tables	4.43	5	5
Provide pictures and visuals	4.14	4	4, 5
Connect learning to similar concepts (scaffolding)	4.14	4	4
Use small group collaboration and discussion	4.00	4	4
Demonstrate real world application	3.86	4	5
Provide a template/model	3.43	4	4
Use inquiry learning (student-led instruction)	3.29	3	3
Work independently (practice alone)	3.00	3	3
Explore the vocabulary	2.71	3	2, 3, 4

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Algebra Content Standard qualitative outcomes. Panel members were asked to provide a rationale for their rating of each practice in the Algebra Content Standard in Round 2 of data collection. A comment on the rationale for the rating of each practice was required before the panel member could proceed to the next practice. Rationales for the practices with a mean rating of 4.0 or above and below 3.0 are presented here.

Panel members, 2B and 4D, provided similar rationales for their rating of 5 on the using graphic organizers, charts, and tables practice, suggesting that this practice would help students extrapolate the formula and see the relationship between the formula and the problem they are solving. Panel members, 4D and 6F, provided similar rationales for their high ratings for the providing pictures and visuals practice, suggesting that this practice helps to build understanding, problem solving skills, and transferability. For the connecting learning to similar concepts (scaffolding) practice, panel members 2B and 6F recommend this practice for the purpose of helping students see the progression to build and sustain knowledge of this content standard. Panel members, 2B and 6F, provided rationales for the using small group collaboration and discussion practice that suggest this practice will help students develop content mastery by owning their work as a team and later applying as individuals. Panel members, 3C and 6F, suggested that the exploring the vocabulary practice may be helpful but is not essential for this content standard.

Geometry Content Standard quantitative outcomes. The data collected from Round 2, Geometry Content Standard is included in Table 9. The responses for each question were examined to locate trends and patterns regarding instructional mathematics practices (see Table 9).

In Round 2, for teaching geometry, the panel rated provide pictures and visuals as the most effective instructional mathematics practice (m = 4.71). The panel also rated *use graphic organizers, charts, and tables* as the least effective instructional mathematics practice (m = 3.43) for teaching geometry.

The most effective instructional mathematics practice for the geometry NCTM middle school mathematics content standard was provide pictures and visuals (m = 4.71), but the next two practices rated by effectiveness were not rated as effective in the previous two standards. Use inquiry learning (m = 3.86) was an instructional mathematics practice rated as effective for the Geometry Content Standard. This practice was not rated as highly effective in the other content standards. Explore the vocabulary (*m* = 3.71) is another instructional mathematics practice the panel felt was more effective to use during geometry instruction.

Demonstrate real life applications (*m* = 3.57) and use graphic organizers, charts and tables (*m* = 3.43) were rated least effective of the mathematics instructional practices shared by the panel when teaching geometry. All of the instructional mathematics practices can be effective when teaching mathematics, but the panel felt that visuals and pictures were more effective than real life application and graphic organizers when teaching geometry.

Table 9

Round 2: Geometry Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Provide pictures and visuals	4.71	5	5
Use inquiry learning (student-led instruction)	3.86	4	5
Explore the vocabulary	3.71	4	4
Connect learning to similar concepts (scaffolding)	3.71	4	4
Use small group collaboration and discussion	3.71	4	3.4
Solve/Demonstrate using technology	3.57	2	2
Demonstrate real world application	3.57	4	2, 4, 5
Use graphic organizers, charts, and tables	3.43	4	4

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Geometry Content Standard qualitative outcomes. Panel members were asked to provide a rationale for their rating of each practice in the Geometry Content Standard. A comment on the rationale for the rating of each practice was required before the panel member could proceed to the next practice. Rationales for the practice with a mean rating of 4.0 or above is presented here. Panel members 1A, 4D, and 6F provided similar rationales for the providing pictures and visuals practice. These panel members suggested the practice of providing pictures and visuals is essential for students to gain an understanding of the geometry content standard; thus allowing students to solve the problems.

Measurement Content Standard quantitative outcome. The data collected from Round 2, Measurement Content Standard is included in Table 10. The responses for each question were examined to locate trends and patterns regarding instructional mathematics practices (see Table 10).

In Round 2, for teaching measurement, the middle school mathematics teacher panel rated provide pictures and visuals as the most effective instructional mathematics practice (m = 4.14). The panel also rated provide a template/model as the least effective instructional mathematics practice (m = 3.29), taking mode into account, for teaching measurement.

The most effective mathematics practice for teaching measurement, provide pictures and visuals (m = 4.14), appeals to visual learners. Measurement requires the use of tools and visual representations to help students to see and apply the measurement process and usually includes pictures and some type of visual. The least effective rated instructional mathematics practices for teaching measurement were solve/demonstrate using technology and provide a template/model. These instructional mathematics practices are helpful, but the panel did not rate them as effective as the other practices.

Table 10

Round 2: Measurement Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Provide pictures and visuals	4.14	4	4
Use small group collaboration and discussion	3.86	4	3
Connect learning to similar concepts (scaffolding)	3.71	4	4
Work independently (practice alone)	3.43	4	4
Use graphic organizers, charts, and tables	3.43	4	4
Demonstrate real world application	3.57	4	2, 4, 5
Use inquiry learning (student-led instruction)	3.43	4	3
Solve/Demonstrate using technology	3.29	4	4
Provide a template/model	3.29	4	2, 4

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Measurement Content Standard qualitative outcomes. Panel members were asked to provide a rationale for their rating of each practice in the Measurement Content Standard. A comment on the rationale for the rating of each practice was required before the panel member could proceed to the next practice. Only rationales for the practice with a mean rating of 4.0 or above are presented here. Panel members, 3C, 6F, and 7G, provided similar rationales for the providing pictures and visuals practice. These panel members recommend this practice because the maps, scales, and other examples that teachers and students can provide through real life pictures helps students demonstrate what they are thinking, which leads to a deeper understanding.

Data Analysis and Probability Content Standard quantitative outcomes. The data collected from Round 2, Data Analysis and Probability is included in Table 11. The responses for each question were examined to locate trends and patterns regarding instructional mathematics practices (see Table 11).

In Round 2, for teaching data and probability, the panel rated use small group collaboration and discussion as the most useful instructional mathematics practice (m = 4.43). The panel also rated work independently as the least useful instructional mathematics practice (m = 2.86), taking mode into account, for teaching data and probability.

The most effective instructional mathematics practice for the data and probability NCTM middle school mathematics content standard connects student learning to the use of small group discussion, and allows them to collect and/or practice manipulating data with support. Small group learning helps to give the students supported practice before moving to independent practice.

The least effective instructional mathematics practice for the data and probability NCTM middle school mathematics content standard refers to the process of students assimilating the data and personally applying and integrating the mathematics content independently. This practice requires students to complete classroom activities without support or interaction with classmates.

Table 11

Round 2: Data and Probability Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Use small group collaboration and discussion	4.43	5	5
Demonstrate real world application	4.29	5	5
Use graphic organizers, charts, and tables	4.14	4	4
Explore the vocabulary	4	4	4
Solve/Demonstrate using technology	3.71	4	4
Connect learning to similar concepts (scaffolding)	3.71	4	4
Provide examples (use different numbers to solve similar problems)	3.43	4	4
Use inquiry learning (student-led instruction)	3.57	3	3
Provide pictures and visuals	3.29	3	3
Provide a template/model	2.71	3	4
Work independently (practice alone)	2.86	3	2, 3

Note. Scores reported ranged from 1 (least effective) to 5 (most effective).

Data Analysis and Probability Content Standard qualitative outcomes. Panel members were asked to provide a rationale for their rating of each practice in the Algebra Content Standard. A comment on the rationale for the rating of each practice was required before the panel member could proceed to the next practice. Rationales for the practices with a mean rating of 4.0 or above and below 3.0 are presented here.

With regard to the using small group collaboration and discussion practice, panel members, 3C and 5E, suggested that having students work together to gather data and come up with a solution will help them develop a stronger understanding than by working alone. Panel members, 1A and 2B, provided rationales emphasizing the importance of demonstrating real world application, suggesting that many of the concepts within this content standard can best be understood through a real world context. Panel members, 1A and 7G, recommended using graphic organizers, charts, and tables as a good way to teach this content standard because it helps with the visualization process. Panel members, 2B, 5E, and 7G, suggested that exploring the vocabulary practice is necessary for this content standard for students to gain the understanding they need to be able to solve problems. Panel members, 1A and 2B, suggested that the practice of providing a template/model would not be a good practice to use in this content standard. One reason suggested for this is that that data from different situations would not fit neatly into a template/model. Panel members, 1A and 3C, suggested using use small groups and collaborative learning would be a more effective practice versus working independently.

Round 3: Final Modified Delphi Round

Each of the seven middle school mathematics teachers on the panel received a survey with the same five content standards from Round 1 and Round 2. As in Round 2, each question (that correlates to a NCTM middle school mathematics content standard) had the 12 instructional mathematics practices listed under it. However, this time, each instructional mathematics practice listed included the mean, median, and mode from Round 2 along with all of the comments provided by each panel member from Round 2.

After reviewing the Round 2 data, each participant was asked one last time to rank the priority of the instructional mathematics practice for teaching the NCTM middle school mathematics content standard by marking the 5-point Likert scale.

The 12 instructional mathematics practices collected from the panel in Round 1 were listed under each question along with the mean, mode, and median data and all comments collected from the panel. The panel was asked to rate each instructional mathematics practice's effectiveness a last time using a Likert scale. This time, the panel was not required to provide an explanation for each rating.

Round 2 data provided the rating and explanations from the group of seven middle school mathematics teacher on the panel for each of the recommended instructional mathematics practices best suited to meet the NCTM middle school mathematics content standard represented by survey content standards 1-5. The purpose of the Round 3 data collection was to allow the panel members view how others on the panel valued each of the instructional mathematics practices generated for the five content standards based on the NCTM middle school mathematics content standards. In other words, each panel member was given the opportunity to rethink his or her own rating for each instructional mathematics practice for each content standard after looking at the instructional mathematics practice ratings including mean, median, mode, and explanations collected from Round 2. With this information, the panel rated everything with a 5-point Likert scale to indicate how essential each instructional mathematics practice would be for instructing the indicated NCTM middle school mathematics content standard.

Each of the seven middle school mathematics teachers on the panel received a survey with the same five content standards from Round 2. This time each content standard had the instructional mathematics practice listed under it ranked in order based on the mean, median and mode based on the ratings from Round 2. Each instructional mathematics practice had a list of explanations collected from the panel during Round 2 sharing the reasoning behind each rating. Each participant was asked to rank the priority of the instructional mathematics practice for teaching the NCTM middle school mathematics content standard by marking the 5-point Likert scale on last time with no explanation. The instructional mathematics practices collected from the panel in Round 1 were listed under each content standard, and the panel was asked to rate each instructional mathematics practices effectiveness using a 5-point Likert scale.

Numbers and Operation Content Standard. The data collected from Round 3, Question 1, which was related to the numbers and operations NCTM middle school mathematics content standard is displayed in Table 12. The instructional mathematics practice are ranked from most effective to least effectvie.

In Round 3, for teaching numbers and operations, the panel rated, demonstrate real world application and connect learning practices to similar concepts, as the most effective instructional mathematics practice (m = 4.71). The panel also rated explore the vocabulary as the least effective instructional mathematics practice (m = 2.29) for teaching numbers and operations.

The top instructional mathematics practices for the numbers and operations standard included: (a) demonstrate real world application, (b) connect learning to similar concepts (scaffolding), (c) use small group collaborations and discussion, and (d) provide examples (use different number to solve different problems). Their means ranged from 4.71 down to 4.43. The next instructional practice dropped down to 3.14.

Table 12

Summary of Round 3: Number and Operations Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Demonstrate real world application	4.71	5	5
Connect learning to similar concepts (scaffolding)	4.71	5	4
Use small group collaboration and discussion	4.57	5	5
Provide examples (use different numbers to solve different problems)	4.43	5	5
Use graphic organizers, charts, and tables	3.14	3	4
Provide pictures and visuals	3.14	3	3
Work independently (practice alone)	3.00	3	2, 3, 4
Use inquiry learning (student-led instruction)	3.00	3	3
Provide a template/model	2.86	3	3
Use colors to help track steps or patterns	2.57	3	3
Explore the vocabulary	2.29	2	2

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Algebra Content Standard. The data collected from Round 3, Question 2, which was related to the algebra NCTM middle school mathematics content standard is displayed in Table 13. The instructional mathematics practices are ranked from most effective to least effective.

In Round 3, for teaching algebra, the panel rated use graphic organizers, charts, and tables and provide pictures and visuals as the most effective instructional mathematics practice (*m* = 4.71). The panel also rated work independently and explore the vocabulary as the least effective instructional mathematics practice (*m* = 2.57) for teaching algebra.

The top instructional mathematics practices for the algebra standard included: (a) use graphic organizers, charts, and tables; (b) provide pictures and visuals; (c) connect learning to similar concepts (scaffolding); and (d) use small group collaboration and discussion. Their means ranged from 4.71 down to 4.43. The next instructional practice dropped down to 3.14.

Table 13

Summary of Round 3: Algebra Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Use graphic organizers, charts, and tables	4.71	5	5
Provide pictures and visuals	4.71	5	5
Connect learning to similar concepts (scaffolding)	4.57	5	5
Use small group collaboration and discussion	4.43	5	5
Demonstrate real world application	3.14	3	3
Provide a template/model	3.00	3	2
Use inquiry learning (student-led instruction)	2.86	3	3
Work independently (practice alone)	2.57	3	3
Explore the vocabulary	2.57	2	2

Note: Scores reported ranged from 1 (least effective to 5 (most effective).

Geometry Content Standard. The data collected from Round 3, Question 3, which was related to the geometry NCTM middle school mathematics content standard is displayed in Table 14. The instructional mathematics practices are ranked from most effective to least effective.

In Round 3, for teaching geometry, the panel rated provide pictures and visuals as the most effective instructional mathematics practice (m = 5.00). The panel also rated use graphic organizers, charts, and tables as the least effective instructional mathematics practice (m = 3.14) for teaching geometry.

The top instructional mathematics practices for the geometry standard included: (a) provide pictures and visuals and (b) use inquiry learning (student-led instruction), Their means ranged from 5.00 down to 4.43. The next instructional practice dropped down to 3.43.

Table 14

Summary of Round 3: Geometry Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Provide pictures and visuals	5.00	5	5
Use inquiry learning (student-led instruction)	4.43	5	5
Explore the vocabulary	3.43	3	3
Connect learning to similar concepts (scaffolding)	3.43	3	3
Use small group collaboration and discussion	3.29	3	3, 4
Solve/Demonstrate using technology	3.29	3	3
Demonstrate real world application	3.29	3	2, 3, 4
Use graphic organizers, charts, and tables	3.14	3	3

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Measurement Content Standard. The data collected for Round 3, Question 4, which was related to the measurement NCTM middle school mathematics content standard is displayed in Table 15. The instructional mathematics practices are ranked from most effective to least effective.

In Round 3, for teaching measurement, the panel rated provide pictures and visuals as the most effective instructional mathematics practice (*m* = 5.00). The panel also rated provide a template/model as the least useful instructional mathematics practice (*m* = 2.71) for teaching measurement.

The top instructional mathematics practices for the measurement standard included: (a) provide pictures and visuals, (b) use small group collaboration and discussion, (c) connect learning to similar concepts. Their means ranged from 5.00 down to 4.43. The next instructional practice dropped down to 3.29.

Table 15

Summary of Round 3: Measurement Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Provide pictures and visuals	5.00	5	5
Use small group collaboration and discussion	4.43	5	5
Connect learning to similar concepts (scaffolding)	4.43	4	4
Work independently (practice alone)	3.29	3	3
Use graphic organizers, charts, and tables	3.29	3	3, 4
Demonstrate real world application	3.29	4	2, 4
Use inquiry learning (student-led instruction)	3.14	3	3
Solve/Demonstrate using technology	3	3	2
Provide a template/model	2.71	3	2, 3, 4

Note: Scores reported ranged from 1 (least effective) to 5 (most effective).

Data Analysis and Probability Content Standard. The data collected for Round 3, Question 5, which was related to the data analysis and probability NCTM middle school mathematics content standard is displayed in Table 16. The instructional mathematics practices are ranked from most effective to least effective.

In Round 3, according to the panel's ratings, for teaching data analysis and probability, use small group collaborations and discussion and demonstrate real world application as the most effective instructional mathematics practice (m = 4.71). The panel also rated work independently as the least effective instructional mathematics practice (m = 2.43) for teaching data analysis and probability.

The top instructional mathematics practices for the data analysis and probability standard included: (a) use small group collaboration and discussion; (b) demonstrate real world application; (c) use graphic organizers, charts, and tables; and (d) explore the vocabulary. Their means ranged from 4.71 down to 4.57. The next instructional practice dropped down to 3.14.

Table 16

Summary of Round 3: Data Analysis and Probability Content Standard

Instructional Mathematics Practices	*m*	Median	Mode
Use small group collaboration and discussion	4.71	5	5
Demonstrate real world application	4.71	5	5
Use graphic organizers, charts, and tables	4.57	5	5
Explore the vocabulary	4.57	5	5
Solve/Demonstrate using technology	3.14	3	3
Connect learning to similar concepts (scaffolding)	3.14	3	3
Provide examples (use different numbers to solve similar problems)	3.14	3	2
Use inquiry learning (student-led instruction)	3.00	3	2
Provide pictures and visuals	3.00	3	2, 4
Provide a template/model	2.71	3	2, 3
Work independently (practice alone)	2.43	3	3

Note: Scores reported ranged from 1 (least important) to 5 (most important).

Synposis. Round 3 was different from Round 2 because it was generated by the middle school mathematics teacher panel with knowledge of one another's thoughts or trends in the group through the sharing of mean, median, mode, and explanations from Round 2. The three most effective instructional mathematics practices identified for each question/ NCTM middle school mathematics content standard were never exactly the same as another question/ NCTM middle school mathematics content standard, but they stayed in the same ranking order for each content standard from the Round 2 results. For just about every question and instructional mathematics practice, the data represented by the mean in the three most effective instructional mathematics practices strengthened. For example, for the Numbers and Operations Content Standard, the mean for the highest ranked instructional mathematics practice, apply real world strategies, increased from 4.14 to 4.71. The mean for the second most effective instructional mathematics practice, connect learning to similar concepts (scaffolding), increased from 4.29 to 4.71, and the mean for the third most effective instructional mathematics practice, use small group collaboration and discussion, increased from 4.00 to 4.57. The only mean of a three most effective instructional mathematics practices that decreased was for the Geometry Content Standard. The mean for the third most effective instructional mathematics practice for both Round 2 and Round 3, explore the vocabulary, decreased from 3.71 to 3.43. The three most effective mathematics practices and rankings for each question did not change from Round 2 to Round 3. The strengthening of the averages appears to demonstrate that the panel was more confident from the previous rankings after being able to view the mean, median, mode, and explanations from all middle school mathematics teachers on the panel from Round 2.

Data Analysis of Complete Project

The data collected in the survey indicated that the panel in the field of middle school mathematics identified 12 instructional mathematics practices that were present in all NCTM middle school mathematics content standards presented at this level. Each of the five questions was connected to one of the NCTM middle school mathematics content standards, but the mathematics instructional practices that were generated and those that were rated most effective by the panel were different for each question/standard. Because of this difference, when searching for the best instructional mathematics practices to use when teaching a question based on an NCTM middle school mathematics content standard, the data support that the instructional mathematics practices chosen to use in instruction should change depending upon which NCTM middle school mathematics content standard is being taught. The results from the data support sharing the instructional mathematics practices with educators separately for each NCTM middle school mathematics content standard because the instructional mathematics practices were ranked differently depending upon the question.

After the panel members viewed the explanations from others when generating the Round 3 data results, the top instructional mathematics practices list stayed the same. The notable connection for this round and the previous round was that the mean data strengthened between Round 2 and Round 3. In other words, the data from Round 3 supports the idea that the panel were more confident that the top instructional mathematics practices were the best ones to use for each of the five questions based on the 5 NCTM instructional mathematics practices. The strong ratings of the top instructional mathematics practices for each question from the panel suggests that teachers could use them to strengthen teaching and learning for each question.

Results Summary

In summary, in this study I collected data from a middle school mathematics teacher panel over three rounds. In Round 1, the panel provided instructional mathematics practices that could be used to help students solve five problems. Each problem matched a NCTM middle school mathematics content standard for middle school mathematics. The instructional mathematics practices were collected for all five questions and coded/grouped into a total of 12 instructional mathematics practice. In Round 2, the instructional mathematics practices collected from Round 1 for each question. The panel was asked to rate the effectiveness of each instructional mathematics practice for each question, and the data was analyzed using mean, median, and mode. The panel also provided reasoning for each instructional mathematics practice rated. For Round 3, the data collected from Round 2 was presented to the panel for each question including the reasoning. The panel rated each instructional mathematics practice's effectiveness for teaching each NCTM content standard one more time after reflecting upon the reasoning provided from the rest of the panel in Round 2. The data collected were shared in Tables 1 through 11 with different instructional mathematics practices rated in the top three for each question.

The mathematics instructional strategies that the panel generated and rated during Round 3 related directly to the problem and research question from the study. The problem was that due to very low state eight grade mathematics scores, a need exists for appropriate learning and critical thinking instructional mathematics practices that help all students master abstract and more difficult middle school mathematics concepts. The Round 3 outcomes in this modified Delphi study included instructional mathematics practices generated and rated by middle school mathematics teacher panel. The panel members believed the instructional strategies generated and rated would help students master mathematic concepts in each of the NCTM mathematics content standards.

The research question also relate to the outcomes from the study. The research question asked “What are middle school mathematics teachers’ perspectives of instructional mathematics practices for abstract mathematics concepts and content taught in an urban middle school in Colorado?” The Round 3 outcomes in this modified Delphi study included instructional mathematics practices generated and rated by middle school mathematics teacher panel. The instructional practices were generated for each NCTM content standard based on the perspectives from the panel. and then were rated according to effectiveness in the Round 3 outcomes.

The conceptual framework for this study relate to many of the outcomes. The NCTM Principles are six principles that are examined that may assist in planning mathematics instructional methods, mathematics learning, and in the creation of top-quality mathematics programs (NCTM, 2000). These six principles (NCTM, 2000) include: (a) equity, (b) curriculum, (c) teaching, (d) learning, (e) assessment, and (f) technology.

Instructional strategies generated by the panel in the Round 3 outcomes relate to the equity principle. This principle is based on the idea that one’s potential to learn mathematics should not be lowered due to extenuating circumstances which could include language deficiencies, socioeconomic status, or disabilities. Instead, this principle asserts that additional resources be used to help all learners meet high mathematics learning expectations. Through the outcomes in Round 3, there were instructional practices generated and ranked at a top level that could meet the equity principle because the practices provide additional resources to help all learners. Provide examples (use different numbers to solve different problems) gives all learners additional resources to help students to be successful in NCTM content standards such as numbers and operations. Use graphic organizers, charts, and tables was an instructional practice providing extra resources to help students especially in the algebra content standard and in data analysis and probability. Provide pictures and visuals also includes a focus on additional resources, and the panel thought it is especially effective when teaching geometry and measurement content standards.

Instructional strategies generated by the panel in the Round 3 outcomes relate to the curriculum principle. This principle is based on the idea that mathematics concepts taught should be worthwhile or have purpose in everyday life, and these connections should be presented in mathematics instruction. Through the outcomes in Round 3, there was an instructional practice generated and ranked at a top level that could help provide connections to students' everyday live. Demonstrate real world application is an instructional practice generated from the outcomes that gives students a chance to make these connections in NCTM content standards such as numbers and operations and data analysis and probability content standards

Instructional strategies generated by the panel in the Round 3 outcomes relate to the teaching principle. An important part of sound teaching that falls under this principle is the creation thought-provoking yet compassionate teaching setting. Through the outcomes in Round 3, a few instructional strategies ranked at a top level can help create a thought-provoking yet compassionate teaching setting. Use small group collaboration and discussion was an instructional practice generated from the outcomes that gives students a chance to make these connections in NCTM content standards such as numbers and operation, algebra, measurement, and data analysis and probability content standards. Use inquiry learning (student led instruction) was another instructional practice generated from the outcomes that does the same thing. This practice was ranked at a high level in the geometry NCTM content standard.

Instructional strategies generated by the panel in the Round 3 outcomes relate to the learning principle. An important part of sound teaching that falls under this principle is that teachers need to provide experiences that provide a deeper meaning and learning level for students through appealing activities and classroom communications (NCTM, 2000). Through the outcomes in Round 3, a few instructional practices ranked at a top level can help create experiences where students attain deeper meaning with appealing activities and communication. These same instructional practices connected to the previous principle discussed, the teaching principle. Use small group collaboration and discussion was an instructional practice generated from the outcomes that gives students a chance to make these connections in NCTM content standards such as numbers and operation, algebra, measurement, and data analysis and probability content standards. Use inquiry learning (student led instruction) was another instructional practice generated from the outcomes that does the same thing. This practice was ranked at a high level in the geometry NCTM content standard.

All instructional strategies generated by the panel in the Round 3 outcomes relate to the assessment principle. An important part of sound teaching that falls under this principle is that the use of assessment as an instrument is one of the best way to make educational decisions (NCTM, 2000). Through the outcomes in Round 3, all instructional practices fit this principle. The first way to apply the practices is to assess students using an instructional practice to gather assessment data. Any of the practices can be assessed informally or formally. The second part of this principle is to make educational decisions based on the assessment data collected. Various instructional practices could be applied to future learning activities as a result of analyzing assessment data. Using assessment as an instrument is one of the best way to make educational decisions (NCTM, 2000).

One instructional strategy generated by the panel in the Round 3 outcomes relate to the technology principle. The technology principle states that teachers should use it in efficient ways to support teaching and learning. In the beginning of the modified Delphi process, the teacher panel generated the instructional practice of solve, demonstrate using technology for three of the NCTM content standards, geometry, measurement, and data analysis and probability. In subsequent rounds, including Round 3 which was used to analyze the outcomes, the technology instructional practice was not ranked at a high level by the teacher panel. Solve, demonstrate using technology was still listed as a possible instructional practice for teaching and learning geometry, measurement, and data analysis and probability in the Round 3 results.

Conclusion

In this section, the research process has been outlined including detailed descriptions of the data collection and data analysis procedures, description of the exploratory, modified Delphi method, reliability and validity processes in the study, data analysis and validation procedures, and participants' rights. The end result of the research included a list of research instructional mathematics practices that the panel selected that are effective in instructing mathematics concepts. The outcomes from Round 3 guided the development of a resource guide that teachers can use to help students learn mathematics by using recommended instructional mathematics practices. The top ranked results for each of the NCTM content standards in Round 3 were used to create the resource guide in a Training Plan project deliverable. This project deliverable provides teachers with a resource where they can find out what these top instructional practices are for each of the NCTM content standards and then apply them in learning activities with students.

In Section 3, the project is described along with the review of literature related to the project. Section 4 of the study includes the researcher's reflections related to the research study and conclusions related to the project study. This section provides a list of implications, applications, and direction for further research.

Section 3: The Project

Introduction

This section includes a brief description of my project (see Appendix A). I chose a professional development training plan for the project format. First, a training plan could help teachers assess their own use of best practice teaching strategies based on the outcomes of this study. Then, a plan could help teachers implement these strategies into their own instruction. Teachers who are using the training plan to improve their mathematics instruction would learn about the instructional mathematics practices suggested by the middle school mathematics teacher panel in the modified Delphi study. Teachers would then use the training plan to help them set goals and create learning activities that incorporate these instructional mathematic practices into classroom learning.

Description and Goals

The training plan was created to provide guidance to teachers but also to allow teachers to be able to choose the practices that work best for their needs and the needs of their students. The training plan includes: (a) purpose; (b) learning outcomes; (c) intended audience: (d) components and a suggested timeline; (e) materials, activities, and trainer notes designed to help teachers learn about using different instructional mathematics practices; and (f) plans and materials for an evaluation plan.

The goals of the training plan are designed to help teachers address the problem of low middle school mathematics achievement by using the instructional mathematicspractices collected from the panel in the modified Delphi study. The goals are: (a) to enable teachers to integrate best practices for middle school mathematics instruction into daily mathematics lessons, and (b) to provide appropriate mathematics instruction to help teachers facilitate improvement in mathematics student achievement.

Rationale

I chose the training plan to address the problem of low middle school achievement on mathematics standardized tests. The data collected from the middle school mathematics teacher panel in the study focused on finding the best instructional mathematics practices to use when teaching, in accordance with NCTM middle school mathematics content standards. The training plan provides a way to share a procedure by which teachers can assess their own instructional methods, integrate best practices, and customize their instruction and assessments (Beswick, 2014).

The training plan includes the purpose of the training plan along with an explanation of the importance of using instructional mathematics practices to help students achieve NCTM middle school mathematics content standards. I designed the training plan as a type of professional development to help teachers achieve teacher self-awareness in relation to the problem of the study. The problem was that, due to very low mathematics scores in the eighth grade state test , mathematics teachers need appropriate instructional mathematics practices that help all students master challenging middle school concepts. The teachers using the training plan are able tocan take the information from the outcomes related to the highest-rated instructional mathematics practices for each of the NCTM standards and learn how to apply them in their mathematics instruction. Thus, students will become a part of instructional activities that can help them to master challenging mathematics concepts.

A novice or experienced teacher can use the training plan by following a few easy steps. Teachers should: (a) read the training plan and consider the highest rated instructional practices for each of the NCTM content standards, (b) apply the training plan by using the checklist to check his or her current use of the instructional mathematics practices shared, and (c) use the information shared in the plan about implementation of highly rated instructional practice instructional practices in his or her lesson planning. This application of highly rated instructional practices benefits students by providing them with different paths to master challenging mathematics topics.

Review of the Literature

The training plan genre is appropriate to the problem from the research. The problem was that due to very low state eight grade mathematics scores, a need exists for appropriate learning and critical thinking instructional mathematics practices that help all students master abstract and more difficult middle school mathematics concepts. The use of best practices or proven instructional mathematics practices collected from the outcomes of the modified Delphi methodology in the study can help to improve student achievement scores. The outcomes from the final round of the study included the highest rated instructional practices from each of the NCTM standards. These highest rated instructional practices are the practices highlighted in the training plan so that teachers can find ways to include them in their instructional practice.

The literature review for professional development included a search to saturate current research regarding professional development of which a training plan is a sub-category. The Walden library databases were searched and included the following terms: *training plan, professional development, professional development and student achievement, math professional development, professional development research, reading professional development, science professional development, social studies professional development*. All recent articles were considered for the literature review.

Training Plan

A training plan is a form of professional development for teachers and might assist professionals better understand best practices related to the profession (Cox, 2015). The best professional development is based on or backward planned from well-defined goals (Guskey, 2014). The goals for this training project are based on the problem of low achievement and the notion of sharing best practices The goals should be the ultimate aim should be to reverse/eliminate/reduce low mathematics achievement. The primary goal, as shared earlier, is to enable teachers to integrate best practices for middle school instruction into daily lessons to facilitate improvement in mathematics student achievement.. Grusky (2014) also observed the benefits of using learner outcomes to prepare professional development training. The project study started with learner outcomes in the problem to guide the methodology and data collection process, which, in turn, led to the decision to use a training plan to help deepen the teacher knowledge of recommended instructional mathematics practices.

Once teachers are made aware of the recommended strategies, professional learning or development works best when the teachers identify his or her needs in relation to the material (Beswick, 2014). This project includes self-evaluation in the training plan that allows teachers to assess their learning needs and to use this to help understand where to grow from the information presented. This pre-assessment or self-assessment benefits teacher and students alike. After teachers learn to effectively apply the recommended instructional mathematics practices in the classroom, the students can benefit from these new instructional mathematics practices to achieve at higher levels.

Benefits

Finding research-based recommended mathematics instructional practices and sharing them through professional development with teachers, helps teachers to broaden their own states of application and knowledge that can help broaden their students' content knowledge. A training plan for this study fits into this philosophy because it helps teachers to broaden practice through self-assessment and application of new instructional mathematics practices shared by the middle school mathematics teacher panel in the modified Delphi study. In the end, higher student achievement should help students to master challenging mathematics concepts when research-based instructional mathematics practices are shared effectively through professional development. According to Shaha and Ellsworth (2013), schools with solid professional development plans performed higher in many areas including the area of student achievement.

Mathematics achievement. A study on teaching mathematics at the elementary level provided results showing that teachers who are strong in pedagogy in mathematics have students that perform at higher achievement levels in students' mathematics assessments (Erskine, 2010). The content knowledge of teachers could be enhanced in several ways with one being targeted professional development. Higher student mathematics achievement could be attained more easily when teachers read and complete the training plan in this project.

Winkler (2011) observed teachers who received professional development in mathematic interactive lesson plans, and the results showed that the teachers participating in this training led to higher student achievement on mathematics assessments. Professional development was used to help teachers with a specific lesson plan format that should help students to learn more easily. This training content is similar to the content of training teachers on best practices in accordance with NCTM mathematics NCTM middle school mathematics content standards. The teachers using the training plan in this study should have students showing higher levels of mathematics achievement such as shown in Winkler's study (2011).

Parrish (2013) observed the effect of professional development on teacher differentiation practices in Grades 3 to 5 mathematics and science achievement. The results showed that for most professional development training, students who were part of the study outperformed the district median level of achievement. Santau, Maerten-Rivera, and Huggins (2011) observed ELL students whose teachers received professional development with regard to science. These students also yielded assessment results that were higher than students whose teachers were not part of the professional development. Santau et al. demonstrated the need to provide effective professional development related to the top mathematics instructional mathematics practices collected from the middle school mathematics teacher panel in the modified Delphi research for this study. The result of the training plan for this project study is to provide a project that generates higher levels of student achievement in middle school mathematics when the teachers implement the training.

Caban-Vazquez (2010) conducted a study in which he determined that teacher training positively impacted student mathematics achievement. An after school mathematics program was the setting for this study. These findings support the idea of using a training plan to educate middle school mathematics teachers regarding recommended teacher instructional mathematics practices collected through the research. The strategies shared in the Caban-Vasquez study are similar to the ones generated by the panel.

Reading achievement. Reading instruction is a content area where research has shown improved student achievement via professional development. Fisher, Frey, and Nelson (2012) established that students received moderate gains in reading achievement because of strategic professional development. Porche and Pallante (2012) also studied the effects of professional development on fourth grade students. Porche and Pallante (2012) concluded that most areas of reading statistically improved for the students. If professional development helps students to succeed in reading instruction, mathematics professional development may show similar results in the training plan for this project study.

Research exists showing positive correlations between professional development and state standardized test achievement scores (Jackson, 2014). In a middle school population, the state achievement scores were analyzed to determine this correlation. Content areas scores included both language arts and mathematics. A goal of this project study plan is to help students achieve at a higher level, so professional development in the form of a training plan might provide results similar to Jackson's study.

Effective Mathematics Professional Development

Beswick (2014) observed mathematics teachers and gathered their perceptions about professional development. The findings indicated that mathematics teachers need to communicate to make professional development meaningful. Liljedahl (2014) also determined that teachers want input into their professional development and that single session workshops are not a favored format. McConnell, Parker, and Eberhardt, (2013) further established the need for pre-assessment of the teachers' learning needs during professional development in order to determine activities that are appropriate based on teacher experiences. Kapanadze, Bolte, Schneider, and Slovinsky (2015) conducted research on the professional development of teachers related to current teaching reforms in science which led to higher student achievement. Cox (2015) noted the support behind different choices that teachers have in professional development, and the training plan for this project offers a choice of training that might be more flexible and in tune with teachers. Suanrong and Herron (2014) emphasized that differentiated training helps to amplify the event for teachers. The training plan allows for teachers to determine what instructional mathematics practices are new and how it can apply to his or her needs, similar to how the training plan from this study should be applied.

Polly, Neale, and Pugalee (2014) established that teachers went through professional development felt better about mathematics instruction and demonstrated improvement in teaching performance. The study included teacher observations, and the results collected described the teachers as showing more knowledge and stronger viewpoints regarding mathematical instruction. Jao and McDougall (2015) concluded that mathematics teachers embrace professional development and appreciate the ability to implement what they had learned within a collaborative community. The training plan will encourage teachers to pursue collaborative professional development, yet the teachers will be able to use the checklist to personalize the training ot his or her personal needs in relation to teaching the NCTM content standards.The training plan from this study should impact mathematics teachers as instructional mathematics practices generated by middle school mathematics teachers that can be used to improve pedagogy and beliefs about how to best teach different NCTM middle school mathematics content standards are provided. This plan can benefit the community of teachers who are all sharing this instructional focus.

Nadelson et al. (2013) studied how teachers perceived professional development with regard to their own value teaching STEM (science, technology, engineering, and mathematics) content. The end result maintained that teachers were confident in their teaching and student learning after professional development. Similar results were obtained in other research (Lane et al., 2015) with regard to teacher feelings of efficacy after professional development in assessment intervention strategies. Abilock, Harada, and Fontichiarof (2013) suggested that professional development opportunities based on specifi teacher needs increase teacher effectiveness in the classroom. Renninger, Cai, Lewis, Adams, and Ernst (2011) advocated the view that teachers preferred training that is learner directed based on each teacher's needs. Teachers will progress through the training plan in this study and will be educated about top instructional mathematics practices collected from the outcomes in the modified Delphi methodology. As a result, teachers may move towards a more positive viewpoint of their own abilities to improve student learning basedon student learning needs

Implementation

The implementation plan in this section was created to direct the training planhe plan also ensures materials, resources, supports and a reasonable timetable are in place. It also defines the roles and responsibilities of the stakeholders who will take part in the plan.

Potential Resources and Existing Supports

The plan includes several resources and existing supports. Resources include the internet and email which allows the training plan to be shared within the school district mentioned in the problem or any other one in the country. Other resources include the data or chosen effective instructional mathematics practices from the panel in the modified Delphi group and research available related to the instructional mathematics practices that can be shared with teachers. Supports include personnel who are already in place to help teachers with mathematics instruction coaching in the school district. These people would be able to communicate with teachers and share the plan and materials.

Potential Barriers

The training plan includes potential barriers as well. One barrier would be time required to complete the training plan. Teachers are busy professionals, and the plan needs to be manageable so that they can fit it in to their schedules and apply the new information along with their regular teaching duties. The training plan is asynchronous, so teachers can fit it in during his or her free hours rather than attending training at a set date, time, and place. Another barrier would include the buy-in from administration within the school district in order to implement it. To help with this issue, the training plan is shared with administration in a debriefing meeting by the researcher as a tool to improve middle school mathematics achievement, which is the overarching problem of the study and throughout the nation. The purpose of the study was to gather research-based teaching and learning instructional mathematics practices that follow best practice and align with the concepts taught and CO’s mathematics standards, which, ultimately, may positively impact middle school students’ mathematics achievement. This purpose is helpful to explain to administration why the project is worth the district’s time and effort for implementation as the project since school district’s might be interested in implementing these instructional practices that could lead to better student achievement in mathematics.

Proposal for Implementation and Timetable

The project implementation and timetable are discussed in this section. First, the purpose and background along with the training plan outline, project explanation and details, pre-assessment checklist, NCTM content standard modules, and project evaluation rubric evaluation regarding the project goals is discussed. The timetable would include 1 day to preview the materials, 1 day to read the project explanation and background, scan the information in the NCTM content standard modules, and to complete the Current Instructional Mathematics Practices Being Used Pre-assessment Checklist that is included in the plan, and 1-3 days to review the new instructional mathematics practices and plan implementation included in the NCTM content standard modules in the project. Additionally, the participant would designate a term (i.e. 6 or 9 weeks term) to use the teaching activities generated from the instructional mathematics practices, and also set aside time on 1 day to evaluate the integration based on the project goals.

Roles and Responsibilities of Student and Others

Roles and responsibilities are shared for the stakeholders—a group that includes the researcher, administrator, teachers completing the training plan, and the students. The researcher is responsible for sharing the project study with local school administration and sharing how to implement the timeline. The administration shares the training plan with local middle school mathematics teachers. The teachers complete the components of the training plan and share results with the researcher. The researcher collects any data generated from the participant evaluations. The students actively participate in lessons that teachers have generated using the new instructional mathematics practices.

Project Evaluation

The project evaluation goal-based design is discussed in this section to include a description, the justification, the overall project goals and evaluation goals, and key stakeholders. The justification for the training plan is based on the goals of the overall project. The purpose of the study was based on including successful teaching and learning instructional mathematics practices infused into existing curricula which could lead to major gains could decrease the achievement gap and encourage student proficiency in mathematics. This purpose connects to the he overall goal for the project which would be to raise student achievement in middle school mathematics based on sharing instructional mathematics practices with teachers to use from the modified Delphi study. One key way to do this is through a training plan where teachers can learn and apply new instructional mathematics practices based on each of their training needs. The project goals are based on a rubric provided to teachers to complete at the end. The rubric has 4 levels with a rating of 4 being the highest. Teachers rate their gain in overall knowledge regarding effective mathematics teaching instructional mathematics practices and rate their perception of student gains in classroom assessment after infusing the new instructional mathematics practices. The key stakeholders are the teachers and the students.

Implications Including Social Change

Local Community

The training plan addresses the needs related to student learning in my local community. Positive implications are stimulated by the plan via the stimulation of higher student achievement. Higher student achievement can demonstrate that students are learning as a result of better teaching and learning practices. The overarching problem of the study is based on low achievement scores for middle school students in mathematics. The modified Delphi study allowed a middle school mathematics teacher panel to share instructional mathematics practices that work well for each of the NCTM middle school mathematics content standards. The effect related to teachers and students engaging in the instructional practices shared could be that students score higher on assessments. When students demonstrate higher test scores, it can be connected to the conclusion that more mathematics learning is occurring as a result from the use of more effective instructional mathematics practices integrated into learning activities. All levels of the educational community might benefit from the implementation of recommended mathematics instructional practices.

The instructional mathematics practices shared and ranked at the top by the modified Delphi study middle school mathematics teacher panel include high energy activities involving small group collaboration and inquiry learning. These suggested instructional mathematics practices energize students to learn. These instructional mathematics practices lead to positive social change in regard to enthusiasm to learning.

The students in the local community develop non-cognitive skills and connections to teachers because of the training plan. Non-cognitive skills include general knowledge, inquisitiveness, art and culture awareness, leadership, interpersonal skills, and public responsibility (Sommerfeld, 2011). These skills developed include ones that are often predictive of future success in academics especially in college. Instructional mathematics practices suggested by the panel and highlighted in the project include ones like small group collaboration, real life application, and inquiry learning that lead to improvement in some of these soft skills.

As teachers self-assess and look for instructional mathematics practices from the modified Delphi study that are not being used, the students may benefit. The students benefit because the teachers build a repertoire of teaching practices that can guide students to mastery of challenging mathematics concepts. Expanding the methods or practices to help students learn mathematics could be a result from teachers stepping out of the traditional mathematics teaching role.

Instructional mathematics practices suggested and used in the project help to build learning more than academic testing and other measurement focused learning requirements. These outside of the box types of skills may lead to success in the workforce (Levin, 2015) The project instructional mathematics practices guide students to develop the non-cognitive skills that are a necessity to be productive in society.

Far-Reaching

In the larger context, the project study provides better instructional practices for students across the country facing a similar problem with low mathematics achievement.

The results collected from the modified Delphi study which were used to design the training plan help just about any middle school mathematics classroom across the country. The instructional mathematics practices rated by the middle school mathematics teacher panel help students no matter their location. Teachers across the country enhance instructional practices by applying the data collected and using the training plan.

Conclusion

The training plan genre and project was the focus of Section 3. It included the description and goals of the project, the rationale and a literature review related to the project genre chosen. This section also contains information regarding implementation of the project and its implications.

Next, in Section 4, the project limitations, strength and scholarship are discussed. This section also allows for reflection on analysis and the project's study's impact on social change. Implications and future research based on the findings are also shared.

Section 4: Reflections and Conclusions

Introduction

This section includes my comments on my strengths, limitations, recommendations, and reflections on the project, which included creating and evaluating the training plan. I also comment on my learning process, the study's implications, applications of the study, and directions for future research.

Project Strengths

In the project study, several project strengths were evident. The first strength is that the genre of the project and the content were directly connected to the problem of the study and the data collected in the modified Delphi study. The problem of low middle school achievement in mathematics was the focus of the study, and the project provides instructional mathematics practices teachers can use to find better ways to instruct students in each of the NCTM mathematics NCTM middle school mathematics content standards. The instructional mathematics practices shared in the project were generated by the middle school mathematics teacher panel using the modified Delphi research method.

A few other project strengths stand out. One helpful characteristic of the training plan genre is that is allows teachers to integrate it into his or her own time schedule. The plan is something to be used on one's own without attending pre-scheduled professional development sessions. Another strength is that the project is geared to each teacher's unique learning needs. The teacher completes a checklist at the beginning of the training that helps to narrow down what instructional mathematics practices are new to his or her teaching experiences. Then, the teacher is able to focus on instructional mathematics practices that he or she has not tried in mathematics instruction based on the information from the training plan.

Recommendations for Remediation of Limitations

Some limitations are evident when examining the project training plan. The panel in a modified Delphi study generally contains a small number of middle school mathematics teachers. This small group helps to build a consensus in a more efficient manner, but a different type of study that samples a large number of middle school mathematics teachers could also be useful in collecting a larger variation in opinions regarding effective mathematics instructional mathematics practices.

Another limitation is the ability to control whether teachers actually participate in the training. Since the training is one that can be completed on a teacher's own schedule in any location, the district loses some control over whether mathematics teachers have actually participated. I recommend districts provide a suggested timeline for completing the training plan and follow-up to see if teachers have completed it. The district could also provide incentives for the teachers to complete it early that might include comp time, extra planning time instead of training on planning days, or something similar.

Some districts may have mathematics teachers strictly following one mathematics curriculum, and this type of plan could limit or interfere with the ability for teachers to apply teaching instructional mathematics practices outside of specific curriculum lesson plans. To avoid this problem, district administrators need to make it clear that teachers may work outside of specified curriculum so they can infuse specific instructional mathematics practices recommended within the training plan.

One limitation to any training plan is getting teachers motivated to utilize the shared instructional mathematics practices. One way to do this would be for teachers to have some say in the training that is part of his or her professional development plan. The district could provide teachers with this training plan and other ideas throughout the year. Teachers are often looking for ideas that can help them to implement effective instructional mathematics practices into instruction, so many may gravitate towards this project training plan.

Scholarship

Scholarship is an area where I have grown throughout the process. The teacher leadership courses helped to prepare me for this journey of growth, and the research process leading to the completed project study has guided me towards the proper forms of research and writing at the doctoral level. I have gained experience in evaluating the quality of my research and that of others along with the ability to understand and use a whole new level of academic vocabulary. I have reached the highest levels of academic scholarship because of the long process from creation to approval of each section of the study.

In the scholarship process, I have learned that there is limited recent research related to mathematics achievement at the middle school level. This knowledge empowered me to move forward and create a study that not only helps teachers, but does so quickly through the completion of the training plan. The knowledge from the study may spur others to use scholarship to study some of the instructional mathematics practices suggested by the panel in the future. I also gained new ideas for personal use in teaching mathematics from my middle school mathematics teacher panel who participated in the modified Delphi study. I will not view mathematics instruction in the same way as a result of my scholarship experiences.

Project Development and Evaluation

The idea to create a project study related to helping students with low mathematics achievement in middle school came from frustration within my own experiences as a mathematics teacher at this level. In my role, I encountered ideas that seemed to help, but much of the curriculum was prescribed; and there was little guidance that helped teachers or room to supplement and add to prescribed instructional mathematics practices. I wanted to study and create a project that helped this problem.

The idea to research the problem I was experiencing with ineffective mathematics curricula and teaching strategies was cultivated as I went through my teacher leadership courses and considered possible research focus for my student and as I developed my prospectus. I focused on a project study because with the goal of creating something that could be applied immediately to help address the problem. I focused on the modified Delphi method as two of my colleagues used this research method to address similar problems related to language arts instruction and professional development. The modified Delphi method was recommended by a colleague's chair at Walden University.

As I conducted this research, I had instructional mathematics practices generated from my middle school mathematics teacher panel for each of the NCTM mathematics middle school NCTM middle school mathematics content standards and needed a project that could be used to share and apply the results to mathematics instruction. The project genre that seemed like the most efficient way to do this was professional development. After further discussion, my chair and URR guided me toward a training plan project. The consensus was that this would be the most useful tool for middle school mathematics teachers not just in my location but anywhere throughout the United States.

The key parts to the training plan that were most helpful and a focus of my development were the goals and evaluation pieces. The goals were directly tied to the problem of low mathematics achievement and to the instructional mathematics practices collected from the modified Delphi research. The checklist at the beginning of the training plan helps teachers to customize the plan to their unique instructional practice experiences and the top recommended instructional mathematics practices from the panel. The rubric at the end helps teachers to evaluate the effectiveness of the plan based on the learning goals.

Leadership and Change

I learned more about myself and mathematics instruction especially in the areas of leadership and change. Leadership and change are natural paths that follow when trying to remedy a problem such as low achievement in mathematics. Change needs to occur because the status quo is not working or showing the desired or required results. Leadership is needed to generate the change.

In my study, I initially was very focused on change since the current mathematics achievement results were so low. After researching the NCTM Principles and examining current research, it was clear that there were instructional mathematics practices the mathematics teachers could be using that would help students to achieve higher results. The modified Delphi research method was used to gather the data from a middle school mathematics teacher panel to help find instructional mathematics practices that could be helpful in making changes to current instructional practices.

I gained in leadership in several ways throughout the study. One place I developed in leadership skills was in the creation of the research surveys and locating and directing participants on my panel in the modified Delphi research. The other place I gained leadership skills was in the creation of the project training plan. I had to think as a leader when looking at the most effective way to bring the instructional mathematics practices to teachers. Looking at teachers as individuals with unique training needs was one leadership principle that I used. I believe the ability to customize the training plan to the individual needs of the teacher will lead to higher teacher motivation to actually apply the knowledge and skills learned from completion of the training plan.

Analysis of Self as Scholar

My analysis of self in the scholarship process included examining the information I gained throughout the doctoral process. My scholarship process included the extensive amount of research I conducted in all phases through the research process and ending with the creation of the project training plan. Throughout all of my work, I have gained in all areas of scholarship.

I learned how to write a problem statement that related to circumstances regarding low mathematics achievement in my school district. Everything I researched and learned was directly based on this problem including searching for current research and researching the NCTM principles. I learned about gaps in mathematics achievement research and some instructional mathematics practices and techniques that appeared to help. My investigation saturated the literature. I felt confident that this study was needed to address the instructional gap in practice.

In the modified Delphi research process, I learned how to go through the process of soliciting and securing participants, how to create and manage surveys, and how to analyze the data I collected. I had little experience in these areas, but now I feel competent in my understanding of other research and in my ability to conduct more research of my own in the future. I think I can only become better at the process if I do move forward with further research in the future. I also plan to focus more on the data collected from this study and find more ways to apply the research to help with the underlying problem of low mathematics achievement in middle school.

In the project creation phase, my scholarship levels again improved, and I learned even more about scholarship and research. I learned quickly that the project needed to connect directly to the problem and research data collected. I learned that there are several models to consider, and I established from the literature that the training plan option works well to connect the results of the study to a useful product for teachers. The components, as well as the stakeholders, were carefully considered in the planning process. Evaluation was something I had not given much consideration before the process began, but I grew to see how important evaluation is in scholarship to determine if the project is effective and how to improve the project.

Analysis of Self as Practitioner

Throughout the process, I saw myself as a practitioner. I was looking for ways to improve in the practice of the art of teaching mathematics so that students could more successful. This part of my background led me to the problem statement, research method, and the idea to share what I had learned with other teachers in the training plan. I recently moved to a new role as a mathematics coach, and the instructional mathematics practices collected from the middle school mathematics teacher panel along with the project will provide resources for mathematics teachers I coach. Through this role, I am in connection with other mathematics coaches who might also utilize the project in their roles supporting teachers. The training plan is a practical tool that I could share with other practitioners depending upon his or her experience and needs.

Analysis of Self as Project Developer

I learned that I had room to grow as a project developer through this process. I learned that to set effective goals, there had to be an underlying problem and research behind the problem. Once those things were established, I had to choose a project that connected the research to the desired outcome that was also feasible. After selecting the project, I was responsible for looking at the components and setting up an evaluation plan to help determine whether the goals were met. Having completed this process, I am now confident that schools and businesses should consider following a similar process when implementing projects.

The Project's Potential Impact on Social Change

The project has a great potential impact for positive social change in my local community as well as the national community. As shared in Section 1, the problem of low mathematics achievement is one that is a problem starting at a small community level but continues to be a trend when looking at the overall mathematics achievement in the United States. The project provides teachers with middle school mathematics teacher-suggested instructional mathematics practices to use when teaching middle school mathematics for each of the NCTM middle school mathematics content standard. The results could include better understanding and higher mathematics achievement at all levels. The instructional mathematics practices are ones that should work anywhere.

Implications, Applications, and Directions for Future Research

The findings from this project study provides implications, applications, and future direction for research in similar topics of study. The problem of low mathematics achievement is one that is common across the United States, and some ideas can be taken from the data and project to use for related research. Any of the suggestions in this section are ones that would take the exploratory nature of the modified Delphi research and use the results to explore further.

I have several suggestions for future research as a result of the work from this study. The instructional mathematics practices collected from the modified Delphi research could be explored further. Researchers could focus on one NCTM middle school mathematics content standard and try adding a few of the effective instructional mathematics practices into a quantitative study to see if adding them did result in higher mathematics achievement. A case study could be another potential study. Researchers can locate teachers who implement one or more of these instructional mathematics practices for each of the NCTM middle school mathematics content standards in their own research study. Future research could include a mixed methods study where the mathematics achievement and motivation of student learners could be study base on one or more instructional mathematics practices suggested from the modified Delphi research. The project itself could be the basis of the research as teachers go through the training and actually apply it to teaching. The possibilities are vast and more research related to the problem of this study would add to the limited amount of current research available on the problem of low middle school mathematics achievement.

Conclusion

In this modified Delphi mixed methods project study, I examined the problem related to middle school mathematics low achievement. My modified Delphi methodology allowed for me to have a middle school mathematics teacher panel in the field reach consensus on mathematics instructional mathematics practices that were recommended to help students. The results of this study included a list of effective instructional mathematics practices that the panel recommended for instruction in each of the NCTM middle school mathematics content standards. Based on the problem and my results, I designed a training plan where teachers learn to self-evaluate their skills and experience in the recommended instructional mathematics practices for each NCTM middle school mathematics content standards. Then, the teachers are provided with application ideas for the NCTM middle school mathematics content standards that they can use in future middle school mathematics instruction.

When designing the project, I considered my findings from the modified Delphi methodology, the problem of low mathematics achievement, and the literature review with regard to using the genre of professional development/training plan to help teachers learn and apply the information from the research. When the teachers apply the plan, the results may lead to an increase in student achievement in middle school mathematics.

References

Alberta Learning (2002). *Instructional strategies*.. Retrieved from http://www.education.alberta.ca/media/352984/is.pdf

Abilock, D., Harada, V. H., & Fontichiarof, K. (2013). Growing schools: Effective professional development. *Teacher Librarian*, 41(1), 8-13. Retrieved from http://www.teacherlibrarian.com/

Allison, T. M. H. (2012). *The impact of classroom performance system-based instruction with peer instruction upon student achievement and motivation in eighth grade math students*. (Doctoral dissertation). Available from ProQuest Dissertations & Theses Full Text Database. (UMI No. 3494418)

Bayazit, İ. (2013). An investigation of problem solving approaches, strategies, and models used by the 7th and 8th grade students when solving real-world problems. *Educational Sciences: Theory & Practice*, *13*(3), 1920-1927. doi:10.12738/estp.2013.3.1419

Beswick, K. (2014). What teachers' want: Identifying mathematics teachers' professional learning needs. *Mathematics Enthusiast*, *11*(1), 83-108. Retrieved from http://www.infoagepub.com/the-mathematics-enthusiast.html

Bottge, B., Rueda, E., Grant, T., Stephens, A., & Laroque, P. (2010). Anchoring problem-solving and computation instruction in context-rich learning environments. *Exceptional Children*, *76*(4), 417-437. Retrieved from http://www.cec.sped.org

Caban-Vazquez, V. (2010). *Exploring a supplemental educational service math program: The math achievement of economically disadvantaged students and teacher* *professional development*. Available from ProQuest Dissertations & Theses Full Text Database. (UMI No. 3433664)

Cave, A., & Brown, C. (2010). When learning is at stake: Exploration of the role of teacher training and professional development schools on elementary students' math achievement. *National Forum of Teacher Education Journal*, *20*(3), 1-21. Retrieved from http://www.nationalforum.com/

Clark, K. (2006). Practices for the use of technology in high schools: A Delphi study. *Journal of Technology and Teacher Education, 14*(3), 481-499. Retrieved from http://www.aace.org/pubs/jtate/

Cohen D. & Crabtree, B. (2006). *Qualitative research guidelines project*. Retrieved from http://www.qualres.org/HomeLinc-3684.html

Cole, J. E., & Wasburn-Moses, L. H. (2010). Going beyond "The Math Wars." *Teaching Exceptional Children*, *42*(4), 14-20. Retrieved from http://journals.cec.sped.org/tec/

Colorado Department of Education (CDE) (2011, August). *Colorado student assessment program results*. Retrieved from http://www.cde.state.co.us/ /cdeassess/index_data.html#2011

Cone, J. D., & Foster, S. L. (2006). *Dissertations and theses from start to finish* (2nd ed.).Washington, DC: American Psychological Association.

Cox, M. (2015). Back to the future professional development. *Knowledge Quest*, 43(4), 46-53. Retrieved from http://knowledgequest.aasl.org/

Creswell, J. W. (2013). *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage Publications, Inc.

Dalkey, N. C. (1969). *The Delphi method: An experimental study of group opinion*. Santa Monica, CA: RAND Corporation. Retrieved from http://www.rand.org/pubs/research_memoranda/RM5888/

Delacruz, G. C. (2011). *Games as formative assessment environments: Examining the impact of explanations of scoring and incentives on math learning, game performance, and help seeking*. (CRESST Report 796). National Center for Research on Evaluation, Standards, & Student Testing (CRESST). Los Angeles, CA: University of California.

Erden, M., & Akgül, S. (2010). Predictive power of math anxiety and perceived social support for students for primary students mathematic achievement. *Journal of Theory & Practice In Education (JTPE)*, *6*(1), 3-16. Retrieved from theory-in-action-the-journal-of-tsi

Erskine, B. M. (2010). *Raising mathematical achievement starts with the elementary teacher: Recommendations to improve content and pedagogical knowledge of elementary math teachers*. Available from ProQuest Dissertations & Theses Global. (UMI No. 759770685).

Fisher, D., Frey, N., & Nelson, J. (2012). Literacy achievement through sustained professional development. *Reading Teacher*, *65*(8), 551-563. doi:10.1002/TRTR.01082

Franklin, K. & Hart, J. (2007). Idea generation and exploration: Benefits and limitations of the policy Delphi research method. *Innovative Higher Education, 31*(4), 237-246. doi: 10.1007/s10755-006-9022-8

Freeman, G. G., & Wash, P. D. (2013). You can lead students to the classroom, and you can make them think: Ten brain-based strategies for college teaching and ?? MISSING WORD? *Journal on Excellence in College Teaching*, *24*(3), 99-120. Retrieved from http://celt.muohio.edu/ject/

Gardner, H. (2006). *Multiple intelligences: New horizons*. New York, NY: Basic Books.

Gasser, K. W. (2011). Five ideas for 21st century math classrooms. *American Secondary Education*, *39*(3), 108-116. Retrieved from Retrieved from http://www.jstor.org/stable/23100426

Gifford, B., Evans, K., Berlin, L., Bai, Y., & Duke University, C. (2011). America's promise alliance: 10 indicators of academic achievement and youth success. center for child and family policy, Duke?

Graeff, T. R. (2010). Strategic teaching for active learning. *Marketing Education Review*, *20*(3), 265-278. doi:10.2753/MER1052-8008200307

Grisham, T. (2009). The Delphi technique: A method for testing complex and multifaceted topics. *International Journal of Managing Projects in Business, 2*(1), 14-21. doi:10.1108/17538370910930545

Guskey, T. R. (2014). Planning professional learning. *Educational Leadership*, *71*(8), 10-16. Retrieved from http://www.ascd.org/publications/educational-leadership.aspx

Halakatti, S. P. (2010). An introduction for exploring the strategic role of learning, teaching, research, and generation in building and evolving brains for optimal capacity. *Bio Science Research Bulletin-Biological Sciences*, *26*(2), 165-174. Retrieved from http://link.springer.com/journal/11966

Holmstrom, A. (2010). District finds the right equation to improve math instruction. *Journal of Staff Development*, *31*(6), 58-60. Retrieved from http://www.learningforward.org/index.cfm

Howe, M., Mundy, M., Kopczynski, L., & Cummins, C. (2012). Louisiana teacher's familiarity, usefulness and recommendation of content literacy strategies. *Journal of Instructional Pedagogies, 8*(6), Retrieved from http://www.aabri.com/jip.html

Hsu, C.C. & Sandford, B. A. (2007), The Delphi technique: Making sense of consensus. *Practical Assessment, Research & Evaluation*, *12*(10), 1-8. Retrieved from http://pareonline.net/

Jackson, J. K. (2012). Use of criterion-referenced competency test data for data-driven instruction: A phenomenological study. ProQuest Dissertations and Theses. (UMI No. 1170594967)

Jackson, T. L. (2014). *Exploring the relationship between professional development and student achievement* (Order No. 3648449). Available from ProQuest Dissertations & Theses Full Text. (1650613019).

Jao, L., & McDougall, D. (2015). The collaborative teacher inquiry project: A purposeful professional development initiative. *Canadian Journal of Education*, *38*(1), 1-22. Retrieved from http://www.csse-scee.ca/CJE/

Kang, H. W., & Zentall, S. S. (2011). Computer-generated geometry instruction: A preliminary study. *Educational Technology Research And Development*, *59*(6), 783-797. doi: 10.1007/s11423-011-9186-5

Kapanadze, M., Bolte, C., Schneider, V., & Slovinsky, E. (2015). Enhancing science teachers' continuous professional development in the field of inquiry based science education. *Journal of Baltic Science Education*, *14*(2), 254-266. Retrieved from http://www.jbse.webinfo.lt/journal.htm

Kay, H., & Swanson, M. (2011). K-8 preservice teachers' attitudes, knowledge, and confidence in application of content literacy strategies. *National Teacher Education Journal*, *4*(4), 23-33. Retrieved from http://www.ntejournal.com/

Kelly, W. J. (2008*). A R.E.A.L. approach to improving student achievement in math.* (Doctoral dissertation, University of Phoenix, 2008). Retrieved from http://search.proquest.com/docview/304332720?accountid=14872. (304332720).

Lane, K. L., Peia Oakes, W., Powers, L., Diebold, T., Germer, K., Common, E. A., & Brunsting, N. (2015). Improving teachers' knowledge of functional assessment-based interventions: Outcomes of a Professional Development Series. *Education & Treatment of Children*, 38(1), 93-120. Retrieved from http://www.educationandtreatmentofchildren.net/

LaVenia, M., Pineau, K. N., Lang, L. B., & Society for Research on Educational Effectiveness, (2010). The predictive validity of critical thinking disposition on middle-grades math achievement. *Society For Research On Educational Effectiveness*, 70(5). 536-544. Retrieved from https://www.sree.org/

Levin, H. (2015). The importance of adaptability for the 21st Century. *Society*, *52*(2), 136-141. doi:10.1007/s12115-015-9874-6

Lewis, R. E. (2011). *The effectiveness of computer-assisted instruction on student math achievement.* Northcentral University). *ProQuest Dissertations and Theses*, 108. Retrieved from ProQuest database. (851515346)

Liljedahl, P. (2014). Approaching professional learning: What teachers want. *Mathematics Enthusiast*, *11*(1), 109-122. Retrieved from http://www.infoagepub.com/the-mathematics-enthusiast.html

Ludwig, S. (2014). Strategies in Teaching Math. *Strategies In Teaching Math -- Research Starters Education*, Retrieved from https://www.ebscohost.com/academic/research-starters-educationhttps://www.ebscohost.com/academic/research-starters-education

Mahmood, K., Iqbal, M. Z., & Saeed, M. (2009). Textbook evaluation through quality indicators: The case of Pakistan. *Bulletin of Education & Research*, *31*(2), 1-27. Retrieved from http://pu.edu.pk/home/journal/32

McConnell, T. J., Parker, J. M., & Eberhardt, J. (2013). Problem-based learning as an effective strategy for science teacher professional development. *Clearing House*, *86*(6), 216-223. doi:10.1080/00098655.2013.826486

McKinney, S., & Frazier, W. (2008). Embracing the principles and standards for school mathematics: An inquiry into the pedagogical and instructional practices of mathematics teachers in high-poverty middle schools. *Clearing House*, *81*(5), 201-210. doi:10.3200/TCHS.81.5.201-210

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM Perception and Preparation: Inquiry-Based STEM Professional Development for Elementary Teachers. *Journal of Educational Research*, *106*(2), 157-168. doi:10.1080/00220671.2012.667014

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

National Mathematics Advisory Panel (NMAP). (2008). *Chapter 6: Report of the Task Group on Instructional Practices.* Retrieved on July 16, 2008, from http://www.ed.gov/about/bdscomm/list/mathpanel/report/instructional-practices.pdf

Nehme, Z. (2011, November). Blogging and the learning of linear algebra concepts through contextual mathematics. *Mathematics Teaching*, 43-48. Retrieved from http://www.atm.org.uk/journal/

Olds, B., Streveler, R., Miller, R., & Nelson, M. (2003). Using a Delphi study to identify the most difficult concepts for students to master in thermal and transport science (Session 1531). *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition.* Retrieved from https://peer.asee.org/

Ozgen, K, & Bindaka, R. (2011). Determination of self-efficacy beliefs of high school students towards math literacy. *Educational Sciences: Theory and Practice, 11*(2), 1085-1089. Retrieved from http://www.edam.com.tr/kuyeb/en/default.asp

Päivärinta, T, Pekkola, S, & Moe, C. Grounding theory from Delphi dtudies (2011, December). *ICIS 2011 Proceedings.* Paper 4. http://aisel.aisnet.org/icis2011/proceedings/researchmethods/4

Polly, D., Neale, H., & Pugalee, D. (2014). How Does Ongoing Task-Focused Mathematics Professional Development Influence Elementary School Teachers' Knowledge, Beliefs and Enacted Pedagogies? *Early Childhood Education Journal*, *42*(1), 1-10. doi:10.1007/s10643-013-0585-6

Porche, M. V., Pallante, D. H., & Snow, C. E. (2012). Professional development for reading achievement. *Elementary School Journal*, *112*(4), 649-671. Retrieved from http://www.press.uchicago.edu/ucp/journals/journal/esj.html

Rapp, K. (2011). School's out for the summer, but online learning is in. *Education Update*, *53*(6), 1-3. Retrieved from http://www.ascd.org/Default.aspx

Renninger, K., Cai, M., Lewis, M., Adams, M., & Ernst, K. (2011). Motivation and learning in an online, unmoderated, mathematics workshop for teachers. *Educational Technology Research & Development*, *59*(2), 229-247. doi:10.1007/s11423-011-9195-4

Robelen, E. (2012). Big shifts anticipated for math instruction. *Education Week*, *31*(29), S24-S30. Retrieved from http://www.edweek.org/ew/index.html

Rutherford, T**.**, Kibrick, M., Burchinal, M., Richland, L., Conley, A.M., Osborne, K, Martinez, M. (2010, May). *Spatial temporal mathematics at scale: An innovative and fully developed paradigm to boost math achievement among all learners*.

Paper presented at the annual meeting of the American Educational Research Association, Denver, CO.

Santau, A. O., Maerten-Rivera, J. L., & Huggins, A. C. (2011). Science achievement of English language learners in urban elementary schools: Fourth-grade student achievement results from a professional development intervention. *Science Education*, *95*(5), 771-793. Doi:10.1002/sce.20443

Schmitz, B., & Perels, F. (2011). Self-monitoring of self-regulation during math homework behaviour using standardized diaries. *Metacognition & Learning*, *6*(3), 255-273. Doi:10.1007/s11409-011-9076-6

Shaffer, D. (2011). *The effects of differentiated instruction on grade 7 math and science scores.* (Doctoral Dissertation, Walden University, 2011). Retrieved from http://search.proquest.com/docview/884225980?accountid=14872

Shaha, S. H., & Ellsworth, H. (2013). Predictors of success for professional development: Linking student achievement to school and educator successes through on-demand, online professional learning. *Journal of Instructional Psychology*, *40*(1-4), 19-26. Retrieved from http://miar.ub.edu/issn/0094-1956

Sherer, J., & Grunow, A. (2010, Summer). 90-day cycle: Exploration of math intensives as a strategy to move more community college students out of developmental math courses. *Carnegie Foundation for the Advancement of Teaching*. Retrieved from http://files.eric.ed.gov/fulltext/ED514359.pdf

Sommerfeld, A. (2011). Recasting Non-Cognitive Factors in College Readiness as What They Truly Are: Non-Academic Factors. *Journal of College Admission*, (213), 18-22.

Stemler, Steve (2001). An overview of content analysis. *Practical Assessment, Research & Evaluation*, *7*(17). Retrieved from http://PAREonline.net/getvn.asp?v=7&n=17

Suanrong, C., & Herron, S. S. (2014). Going against the grain: Should differentiated instruction be a normal component of professional development. *International Journal of Technology in Teaching & Learning*, *10*(1), 14-34. Retrieved from http://www.sicet.org/journals/ijttl/ijttl.html

Swanson, H. L. (2014). Does cognitive strategy training on word problems compensate for working memory capacity in children with math difficulties. *Journal of Educational Psychology*, *106*(3), 831-848. Retrieved from http://www.apa.org/pubs/journals/edu/

Vale, C., Davies, A., Weaven, M., Hooley, N., Davidson, K., & Loton, D. (2010). Leadership to improve mathematics outcomes in low SES schools and school networks. *Mathematics Teacher Education & Development*, *12*(2), 47-71. Retrieved from http://mathforum.org/mathed/professional.dev.html

Williams, D., Boone, R,. & Kingsley, K. (2004). Teacher beliefs about educational software: A Delphi study. *Journal of Research on Technology in Education*, *3*(36), 213-222. Retrieved from http://www.iste.org/learn/publications/journals/jrte.aspx

Williams, N. L. (2010). *Reversing the math trajectory: An investigation of the factors to which mathematically successful African-American high school students attribute their success.* (Doctoral dissertation, North Carolina Agricultural and Technical State University, 2010). Retrieved from *ProQuest Dissertations & Theses Full Text Database*

Wilson, S. W. (2009). Elementary school mathematics priorities. *American Association of School Administrators Journal of Scholarship & Practice*, *6*(1), 40-49. Retrieved from http://www.aasa.org/publications/jsp.cfm

Winkler, R. L. (2011). *Investigating the impact of interactive whiteboard professional development on lesson planning and student math achievement* (Order No. 3450901). Available from ProQuest Central. (865807880).

Woolley, M. E., Strutchens, M. E., Gilbert, M. C., & Martin, W. (2010). Mathematics success of black middle school students: Direct and indirect effects of teacher expectations and reform practices. *Negro Educational Review*, *61*(1-4), 41-59. Retrieved from http://thener.org/

Xiong, I. (2010, January 1). Innovative instructional strategies and improved math learning among Grades 2 to 6 students. *ProQuest LLC.*

Yousuf, M. (2007). The Delphi technique. *Essays in Education*, 20(2), 80-89. Retrieved from http://www.usca.edu/essays/vol20spring2007.html

Appendix A: The Project

Finding the Best Teaching Instructional Mathematics Practices for Middle School Math
Training Plan Outline

Outline and Time frame for the Project

Module Target Area	**Outline**	**Timeframe**
Pre-Assessment Checklist and Background	• Completes instructional mathematics practice checklist for each NCTM middle school mathematics content standard. • Reads directions for the project.	30 minutes
Numbers and Operations Module	• Reads through numbers and operations recommended instructional mathematics practices • Focuses on instructional mathematics practices that were not checked off. • Integrates at least one of the instructional mathematics practices into an upcoming lesson plan.	1 to 4 hours
Algebra Module	• Reads through algebra recommended instructional mathematics practice • Focuses on instructional mathematics practices that were not checked off. • Integrates at least one of the instructional mathematics practices into an upcoming lesson plan.	1 to 4 hours
Geometry Module	• Reads through geometry recommended instructional mathematics practices • Focuses on instructional mathematics practices that were not checked off. • Integrates at least one of the instructional mathematics practices into an upcoming lesson plan.	1 to 4 hours
Measurement Module	• Reads through measurement recommended instructional mathematics practices • Focuses on instructional mathematics practices that were not checked off.	1 to 4 hours

	• Integrates at least one of the instructional mathematics practices into an upcoming lesson plan.	
Data Analysis and Probability Module	• Reads through data analysis and probability recommended instructional mathematics practices • Focuses on instructional mathematics practices that were not checked off. • Integrates at least one of the instructional mathematics practices into an upcoming lesson plan.	2 to 4 hours
Evaluation	• Complete final evaluation for the project	30 minutes

Project Explanation and Details

This project includes a training plan with modules that are recommended to be completed by middle school mathematics teachers in the district. The project was created for two goals. The first is to help teachers raise middle school student mathematics achievement. The second is to take instructional mathematics practices recommended by the middle school mathematics teacher panel in the modified Delphi study and to use these instructional mathematics practices in instruction for each of the NCTM middle school mathematics content standards in order to help students understand better. The project is divided into pre-assessment, NCTM middle school mathematics content standard modules, and an evaluation at the end. It can be completed during teacher available timeframe or during a district recommended timeframe. Overall, it should not take more than 22 hours at the most to complete.

The middle school mathematics teacher panel in the modified Delphi study suggested instructional mathematics practices for each of the NCTM instructional mathematics practices. The top three instructional mathematics practices for each NCTM middle school mathematics content standard are the focus of this training plan. The modules are broken down by NCTM middle school mathematics content standard and each module contain an explanation of the instructional mathematics practice along with suggestions on how to integrate them into lessons.

The instructional mathematics practices suggested by the middle school mathematics teacher panel for all NCTM middle school mathematics content standards and can all be categorized into the following list:

- Real world application
- Use of technology
- Small group collaboration and discussion
- Vocabulary
- Template/model
- Colors to help track steps or patterns
- Connections to similar concept strategies/scaffolding
- Independent practice
- Use different numbers to solve similar problems
- Inquiry learning/student led instruction
- Pictures and visuals

The top five s instructional mathematics practices were not the same for each NCTM middle school mathematics content standard after the data was analyzed. Part of the training is to show which ones might be better for one than another. And, of course, explanation is given for each one including how to use it in a lesson.

The training is helpful because it is some of the first data collected regarding middle school mathematics instruction. After extensive searching, there was very little on this topic at all. In fact, mathematics at any grade level was not a common topic in recent research. The results could really help students to make some strong gains.

The next step is to fill out the instructional mathematics practice checklist. It can be used as a guide on the modules and instructional mathematics practices that teachers would want to focus. The checklist also helps to differentiate the training so that it meets each teacher’s unique needs.

INSTRUCTIONAL MATHEMATICS PRACTICES PRE-ASSESSMENT CHECKLIST

Directions: Check the instructional mathematics practices that you use often when teaching each specific NCTM middle school mathematics content standard. You will want to focus on the ones that you don't check when working through the training modules.

Numbers and Operations

___ Demonstrate real world application

___ Connect learning to similar concepts (scaffolding)

___ Use small group collaboration and discussion

___ Provide examples (use different numbers to solve different problems)

Algebra

___ Use graphic organizers, charts, and tables.

___ Provide pictures and visuals

___ Connect learning to similar concepts (scaffolding)

___ Use small group collaboration and discussion

Geometry

___ Provide pictures and visuals

___ Use Inquiry learning (Student-led instruction)

Measurement

___ Provide pictures and visuals

___ Use small group collaboration and discussion

___ Connect learning to similar concepts (scaffolding)

Data and Probability

___ Use small group collaborations and discussion

___ Demonstrate real world application

___ Use graphic organizers, charts, and tables

___ Explore the vocabulary

<u>MODULE 1 – NUMBERS AND OPERATIONS INSTRUCTIONAL MATHEMATICS PRACTICES</u>

Directions: Use your checklist to guide you. You can review any of the material, but focus on the instructional mathematics practices that were not checked off. When done reading through the ideas, choose at least one instructional mathematics practice to integrate into an upcoming lesson.

Demonstrate real life application

Real life application is important to use in all types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school numbers and operations problems. The middle school mathematics teacher panel chose this as the number one instructional mathematics practice. It means that you want to take numbers and operations problems and apply the numbers and symbols to real life situations.

Example: There link below provides guidance and examples on how to integrate numbers and operations into the real world. The examples include ideas such as using number cards, favorite number collage, internet number research, hundreds chart, class graphs, estimation experience, home-school connections, and link numbers to other cultures.

- http://www.ldworldwide.org/educators/strategies-for-successful-learning/1105
- Which one would work the best in one of your lessons?
- Create an outline of a lesson where you use one or more of the instructional mathematics practices.

Connect Learning to Similar Concepts (Scaffolding)

Connecting learning to similar concepts (scaffolding) helps students in all types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school numbers and operations problems. The numbers and operations standard NCTM middle school mathematics content standard connects to all of the NCTM middle school mathematics content standards, and is pretty much the building block to learn different kinds of math. The panel chose this as the number two instructional mathematics practice. This means that you want to demonstrate how to use the numbers and operations NCTM middle school mathematics content standard to solve other NCTM middle school mathematics content standards in mathematics such as algebra problems or data analysis. Some examples are provided below.

Example 1: Students are working towards finding measures of central tendency such as mean, median, and mode. The students might also be working on higher levels of statistical understanding including mean absolute deviation (MAD). Start with small sets of data, and allow the students to practice adding, and dividing the numbers without calculators. They can always check their work with calculators. Make it very clear that they are applying skills learned from numbers and operations; if the students did not know the basic calculations, the statistical measurements could not be figured out.

Example 2: Students are working on geometry with complementary, supplementary, vertical, and adjacent angles to find the missing angle measurements in a figure. The students need to know concepts to solve these types of problems including that vertical angles measure the same, supplementary angles added together equal 180 degrees and that complementary angles added together equal 90 degrees. The students need to do many simple subtraction problems to find the missing measurements, so a calculator would not be needed. Make it very clear that they are applying skills learned from numbers and operations; if the students did not know the basic calculations, the missing measurements could not be figured out.

Example 3: Create a class chart to add to as the school year progresses based on numbers and operations skills. As students encounter new lessons, have them add to the chart the many mathematics skills learned throughout the year that require strong numbers and operations skills. This instructional mathematics practice helps to motivate the students by showing them the relevance of numbers and operations skills.

Use Small Group Collaboration and Discussion

Using small group collaboration and discussion helps students in all types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school numbers and operations problems. Numbers and operations connects to all of the NCTM middle school mathematics content standards, and is pretty much the building block to learn different kinds of math. The panel chose this as the number three instructional mathematics practice. It is based on the importance of communication skills and social interaction in learning and helps to build understanding by providing opportunities for students to discuss and explore numbers and operations concepts in small groups.

Example 1: Students are working, adding and subtracting integers which include both positive and negative numbers in numbers and operations skills. Small groups can work on instructional mathematics practices to show others why you get certain answers. Groups can work on using number lines together to help demonstrate how to find solutions to problems like this. Groups can be challenged to write or communicate the steps amongst themselves or share with the class. The groups can create charts or other ways to demonstrate their examples.

Example 2: Students are working towards manipulating rational numbers to include adding, subtracting, multiplying, dividing, and converting among different forms. For any of these lessons, students can work in small groups and or partners to work through sample problems together. The communication provides them with a small support network to help scaffold the learning. Mixed ability groups can also help the lower students to see higher levels of modeling and can help the higher students develop a deeper understanding to be able to explain steps and help other group members.

Provide Examples (Use Different Numbers to Solve Different Problems)

Using different numbers to solve different problems helps students in all types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school numbers and operations problems. Numbers and operations connects to all of the NCTM middle school mathematics content standards, and is pretty much the building block to learn different kinds of math. The panel chose this as the number four instructional mathematics practice. It is based on idea of giving students opportunities to practice with similar problem structure with different numbers.

Example 1: Students are working, adding and subtracting integers which include both positive and negative numbers in numbers and operations skills. Small groups can work on a few problems with different numbers to scaffold the learning process. Next, the students can work similar problems as the ones worked on in small groups with different numbers. This provides students with a scaffolded learning process using similar problem structure. The only difference is the new numbers.

Example 2: Students are working towards adding mixed fractions. For any of these lessons, students can work in small groups and or partners to work through sample problems together. Then, the students could move on to independent practice with this concept with similar problem structures but with different fractions inserted. This structured and scaffolded practice helps the students build confidence and move towards independent understanding with adding mixed fractions.

MODULE 2 – ALGEBRA INSTRUCTIONAL MATHEMATICS PRACTICES

Directions: Use your checklist to guide you. You can review any of the material, but focus on the instructional mathematics practices that were not checked off. When done reading through the ideas, choose at least one instructional mathematics practice to integrate into an upcoming lesson

Use Graphic Organizers, Charts, and Tables

Using graphic organizers, charts, and tables can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school algebra problems. The middle school mathematics teacher panel chose this as the number one instructional mathematics practice. It means that you want to use graphic organizer, charts, and/or tables to help students document concrete understanding needed to solve algebra related problems.

Example: There are a number of graphic organizers that can be used for a variety of algebra topics in the link below. Explore the many charts. As you scroll down, some topics that you can explore include single equations and inequalities, systems of equations, polynomials, graphing an equation of a line and slope.

- http://www.dgelman.com/graphicorganizers/
- Is there a chart or more that you can integrate into an upcoming lesson?

Provide Pictures or Visuals

Using pictures or visuals can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school algebra problems. The middle school mathematics teacher panel chose this as the number two instructional mathematics practice. It means that you want to use pictures or visuals to help the visual learners in the classroom when working on algebra problems.

Example: Simple algebra equations can be drawn by the teacher or student to understand a problem better. For example, you could have the equation 2x + 1 = 5. Students can draw 2 bags with an x or an unknown common amount in each of something. It could be candy or pennies or really anything. Then, add one more of the questions to the picture and show it equal to five of the questions in the visual. Then, show the students how to work backwards from the picture on both sides of the equal sign to keep it balanced. So, if you remove one of the questions from both sides, you have 2 equal bags with an unknown amount equal to 4. Guide the students to come up with ways to find this amount in the bags. As a group, usually they see that you need to divide both sides in half, and you end up with 2 items in each bag. Challenge students to create visuals with their own drawings of each step in the problem. This instructional mathematics practice can be used for just about any problem where you are solving for an unknown or a missing variable.

Connect Learning to Similar Concepts (Scaffolding)

Connecting learning to similar concepts or scaffolding can help learners in most types of mathematics instruction so it makes a great deal of sense to integrate it into middle school algebra problems. The middle school mathematics teacher panel chose this as the number three instructional mathematics practice. It includes building off of mathematics skills including factoring, integer operations, and understanding and being able to use mathematics properties.

Example: In order for students to be able to work through algebra problems, there are many concepts that are part of problem-solving that students need to be able to move forward successfully. The link below can be used in many ways to help students. It includes an algebra readiness assessment, lessons and practice on integers including all operations, distributive property, and simplifying algebraic expressions. The site also includes extra practice problems. The lessons could be inserted as mini-lessons or during a short spiral time in instruction. The lessons could be inserted into a skills portion of the class.

- http://www.algebra-class.com/basic-algebra.html
- How do you see yourself using this site to help with connecting learning or scaffolding in your mathematics classes?

Use Small Group Collaboration and Discussion

Using small group collaboration and discussion helps students in all types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school numbers and operations problems. Algebra concepts build as students move through middle school math. Algebra is also part of the NCTM middle school mathematics content standards. The panel chose this as the number four instructional mathematics practice. It is based on the importance of communication skills and social interaction in learning and helps to build understanding by providing opportunities for students to discuss and explore numbers and operations concepts in small groups.

Example 1: https://www.teachingchannel.org/videos/teaching-with-group-work In this Teaching Channel video, Algebra Team: Strategies for Group Work, a few teacher’s are profiled. The teachers share their strategy for team discussion. Take notes and think of ways to use these teacher’s ideas in your own algebra instruction.

MODULE 3 – GEOMETRY INSTRUCTIONAL MATHEMATICS PRACTICES

Directions: Use your checklist to guide you. You can review any of the material, but focus on the instructional mathematics practices that were not checked off. When done reading through the ideas, choose at least one instructional mathematics practice to integrate into an upcoming lesson.

Provide Pictures and Visuals

Using pictures or visuals can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school geometry problems. The middle school mathematics teacher panel chose this as the number one instructional mathematics practice. It means that you want to use pictures or visuals to help the visual learners in the classroom when working on geometry problems. Manipulatives are one of the best ways to do this in geometry.

Example: There are a number of virtual manipulatives that can be used in all of the NCTM middle school mathematics content standards. One amazing resource that you should explore is the National Library of Virtual Manipulatives (NLVM). The link is copied below. Some of the most useful for middle school geometry include the ones marked for helping students understand transformations, geoboards, and the Pythagorean Theorem. Explore the manipulatives and consider how you might integrate them into your teaching.

- http://nlvm.usu.edu/en/nav/topic_t_3.html
- Which manipulative(s) did you decide to integrate?

Use Inquiry Learning (Student-led Instruction)

Using inquiry learning can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school geometry problems. The middle school mathematics teacher panel chose this as the number two instructional mathematics practice. It means that you want to let students work together and/or independently to determine the best way to find the solution to a geometry problem. In geometry, much of it is proving things to be true so this instructional mathematics practice fits the topic very well.

Example: A website full of inquiry learning lesson plans for geometry at middle and high school levels is copied below. It is very helpful that the lessons are all planned around inquiry-learning instructional mathematics practices. Some of the ones that stood out included teaching the students about the Pythagorean Theorem and Exploring Similarity at the very bottom. Look through the resource for lessons that you might be able to use with your mathematics students.

- http://www.math.uakron.edu/amc/GeometryLessons.htm
- Which lesson is one that you will try to integrate into one of your geometry lessons?

MODULE 4 – MEASUREMENT INSTRUCTIONAL MATHEMATICS PRACTICES

Directions: Use your checklist to guide you. You can review any of the material, but focus on the instructional mathematics practices that were not checked off. When done reading through the ideas, choose at least one instructional mathematics practice to integrate into an upcoming lesson.

Provide Pictures and Visuals

Using pictures or visuals can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school geometry problems. The middle school mathematics teacher panel chose this as the number one instructional mathematics practice. It means that you want to use pictures or visuals to help the visual learners in the classroom when working on geometry problems. Manipulatives are one of the best ways to do this in geometry.

Example: There are a number of virtual manipulatives that can be used to help with the measurement NCTM middle school mathematics content standard at the National Library of Virtual Manipulatives (NVLM) website below. Some of the more helpful ones include the one for converting units and the geoboards.

- http://nlvm.usu.edu/en/nav/topic_t_4.html
- Which manipulatives did you decide to integrate?

Use Small Group Collaboration and Discussion

Using small group collaboration and discussion can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school measurement problems. The middle school mathematics teacher panel chose this as the number two instructional mathematics practice. It means that you want to work in a group setting to help students practice and communicate mathematics learning before applying it independently.

Example 1: Students are working on measurement when learning about similarity and congruence. Small groups can work on instructional mathematics practices to show others why you get certain answers. Groups can work on using charts or virtual manipulatives together to help demonstrate how to find solutions to problems like this. Groups can be challenged to write or communicate the steps amongst themselves or share with the class. The groups can create charts or other ways to demonstrate their examples.

Example 2: Students are working towards finding perimeter and area of regular and irregular shapes. For any of these lessons, students can work in small groups and or partners to work through sample problems together. The communication provides them with a small support network to help scaffold the learning. Mixed ability groups can also help the lower students to see higher levels of modeling and can help the higher students develop a deeper understanding to be able to explain steps and help other group members.

Connect Learning to Similar Concepts (Scaffolding)

Connecting learning to similar concepts (scaffolding) can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school measurement problems. The middle school mathematics teacher panel chose this as the number three instructional mathematics practice. It means that you want to work in a group setting to help students practice and communicate mathematics learning before applying it independently.

Example: Students are working on measurement need to learn basic concepts ahead of time. The website link below provides an overview of the topics required. Read through the list and determine how you might integrate this into your current lessons. You could spiral them in as mini-lessons or even teach them in a separate skills block.

- Are there any that were surprising to you?
- http://www.nzmaths.co.nz/measurement-information
- What is your plan to reconnect students to these concepts when teaching measurement?

MODULE 5 – DATA ANALYSIS AND PROBABILITY

Directions: Use your checklist to guide you. You can review any of the material, but focus on the instructional mathematics instructional practices that were not checked off. When done reading through the ideas, choose at least one instructional mathematics practice to integrate into an upcoming lesson.

Use Small Group Collaboration and Discussion

Using small group collaboration and discussion can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school data analysis and probability problems. The middle school mathematics teacher panel chose this as the number one instructional mathematics practice. It means that you want to work in a group setting to help students practice and communicate mathematics learning before applying it independently.

Example 1: Students are working on data analysis when learning about plotting data on dot plots, histograms and box plots. Small groups can work on instructional mathematics practices to show others why you get certain answers. Groups can work on using charts or virtual manipulatives together to help demonstrate how to find solutions to problems like this. Groups can be challenged to write or communicate the steps amongst themselves or share with the class. The groups can create charts, technology, or other ways to demonstrate their examples.

Example 2: Students are working towards finding independence and conditional probability. For any of these lessons, students can work in small groups and or partners to work through sample problems together. The communication provides them with a small support network to help scaffold the learning. Mixed ability groups can also help the lower students to see higher levels of modeling and can help the higher students develop a deeper understanding to be able to explain steps and help other group members.

Demonstrate Real World Application

Demonstrating real world application can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school data analysis and probability problems. The middle school mathematics teacher panel chose this as the number two instructional mathematics practice. It means that you want to find real life situations where you can use data analysis and/or probability to solve a problem.

Example: Students are working on data, collecting it, bias, etc. You can use the link below to view several videos from a teacher development that lets the teachers experience lessons with real life application. In this link there are 4 video clips, but you can explore the site more to find lesson plans for real life data collection and application as well. View the short videos and think about how you can integrate these instructional mathematics practices into your data analysis and probability lessons.

- http://www.learner.org/courses/learningmath/data/session1/video.html#

Use Graphic Organizers, Charts, and Tables

Using graphic organizers, charts, and tables can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school data analysis and probability problems. The middle school mathematics teacher panel chose this as the number three instructional mathematics practice. It means using charts and other visuals to help display data that has been collected and/or analyzed.

Example: Students are working on data and analyzing it for data analysis and/or probability. Study the huge number of graphic organizers at the site below. Think about how some of the charts could be used to explain the process, show how parts are connected to one another, or display results. How can you integrate one or more charts into some upcoming data analysis and probability lessons?

- http://www.enchantedlearning.com/graphicorganizers/
- Did you choose at least 2 graphic organizers? Think about how you might model how to use it first before letting the students use it on their own.

Explore the Vocabulary

Exploring the vocabulary can help learners in most types of mathematics instruction, so it makes a great deal of sense to integrate it into middle school data analysis and probability problems. The middle school mathematics teacher panel chose this as the number four instructional mathematics practice. It means that you want to help students understand related vocabulary at a deep level which leads to students being apply to apply the vocabulary to their mathematics activities and problems better.

Example: Students are working on data and analyzing it for data analysis and/or probability. The students need some understanding of related vocabulary to help them understand data analysis concepts. The following websites can help students develop data analysis and probability vocabulary

- https://quizlet.com/8734269/data-analysis-vocabulary-flash-cards/
- https://quizlet.com/14594771/probability-vocabulary-flash-cards/
- How did these resources help you to better understand the needed vocabulary?

PROJECT EVALUATION RUBRIC

Directions: Please complete this rubric after the training plan has been completed and at least one or more lessons have been integrated with instructional mathematics practice s/resources from the plan.

Student Name: ________________________________

CATEGORY	4	3	2	1
Project helped students reach higher achievement on lesson objectives.	All students performed at a high level on the lesson or lessons where project strategies were integrated.	Most students performed at a high level on the lesson or lessons where project strategies were integrated.	Some students performed at a high level on the lesson or lessons where project strategies were integrated.	Few to no students performed at a high level on the lesson or lessons where project strategies were integrated.
New Math Strategies/Resources	Many new or never used math strategies were learned from the project for various NCTM standards.	Some new or never used math strategies were learned from the project for various NCTM standards.	A few new or never used math strategies were learned from the project for various NCTM standards.	No new or never used math strategies were learned from the project for various NCTM standards.

Please provide any additional thoughts or suggestions that might help to improve the training plan below.

Appendix B: Invitation to Participate E-mail

TITLE OF STUDY: Mathematics Experts' Perspectives of Teaching Strategies for Middle School Mathematics

Dear Colleague:

I am a doctoral student at Walden University and would like to invite you to participate in a research study by completing three separate online surveys that will take no more than 15 to 30 minutes each of your time. As someone who possesses an expert knowledge of best strategies to use when teaching mathematics to adolescent learners, you were selected as a potential participant in this study because I am researching the most effective strategies to use when teaching middle school mathematics and am gathering a consensus of expert opinions on this topic. Your feedback is quite valuable in determining what strategies mathematics teachers should be using in middle school classrooms.

- **Background Information:** The purpose of this study is to come to a consensus on teaching strategies that could positively impact middle school mathematics achievement.

- **Procedures:** If you agree to be in this study, you will be asked to participate in 3 Rounds of electronic data collection via Survey Monkey. Each survey will take 15-30 minutes of your time and can be completed on a computer of your choice at a convenient time. The 3 Rounds request that you do the following:

  Round 1: Provide strategies that will be useful in teaching NCTM standards in math
  Round 2: Rate the effectiveness of a combined list of strategies and provide your explanation for ranking them in that way.
  Round 3: Look at Round 2 comments from other experts, and then rate the strategies one last time

  Here is a sample question:

  > *Please give a detailed description of how you would facilitate student understanding/learning of the following topics using one or more strategies. Please include exemplar problems or contexts that you would use as well as the instructional strategies you would employ and why.*
  >
  > **Number and Operations**: Please describe the specific strategies you would use to support students as they learn to understand and use ratios and proportions to represent quantitative relationships. The following sample problem is one that students should be able to solve at a proficient level.

A car travels 140 miles on 10 gallons of fuel. How far can it go on a tankful of gas if the tank holds 15 gallons?

- **Voluntary Nature of the Study:** This study is voluntary. Everyone will respect your decision of whether or not you choose to be in the study. No one at Walden University or at your employer will treat you differently if you decide not to be in the study. If you decide to join the study now, you can still change your mind later. You may stop at any time.

- **Risks and Benefits of Being in the Study:** Being in this type of study involves some risk of the minor discomforts that can be encountered in daily life, such as fatigue or stress. Being in this study would not pose risk to your safety or well-being.

  The study's benefits include the potential to identify and provide mathematics teaching and learning strategies that can help middle school mathematics students' achievement levels.

- **Payment:** No payment will be provided in exchange for participation in this study.

- **Privacy:** Any information you provide will be kept confidential. The researcher will not use your personal information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in the study reports. Data will be kept for a period of at least 5 years, as required by the university.

- **Contacts and Questions:** You may ask any questions you have now or later by contacting the researcher via email at xxxxx.xxxxxxx@waldenu.edu or at xxx-xxx-xxxx. If you want to talk privately about your rights as a participant, you can call Dr. First Last. She is the Walden University representative who can discuss this with you. Her phone number is 1-800-925-3368, extension 1210. Walden University's approval number for this study is **IRB will enter approval number here** and it expires on **IRB will enter expiration date.**

- **Participant Requirements:**

  (a) at least 5 years of experience with the adolescent student,

  (b) a graduate degree in an education-related field, and

  (c) at least 3 years of experience teaching mathematics to adolescent learners.

Statement of Consent: I have read the above information and understand the purpose and voluntary nature of the study. By submitting my survey responses, which include checking next to each one of the participant requirements, using the link below, I give my consent to participate confidentially in the study. I acknowledge that I may save or print a copy of this letter for my records.

PLACE LINK TO SURVEY HERE

Appendix C: Initial Participant Selection Email

TITLE OF STUDY: Finding the Best Teaching Strategies for Middle School Math

(Name of participant) ___________,

You are invited to participate in a project study because you have at least 5 years of experience teaching, an advanced degree or higher in an education-related area, and at least three years teaching mathematics to adolescents. The purpose of this study is to examine mathematics experts' perspectives of instructional strategies for abstract mathematics concepts and content taught in an urban middle school in Colorado. The outcome of this study is to create a project for teachers that could be used to improve student performance as measured by state standardized tests.

If you meet the qualifications listed above and are interested in participating please respond to this email briefly listing your qualifications along with a statement of interest in helping me with my study.

Your participation in this study is voluntary. This means that refusing or discontinuing participation involves no penalty. You participation will be kept confidential as well as any information you provide. I, as the researcher will not use your information for any purposes outside of this research project. Also, I will not include your name or anything else that could identify you in any reports of the study.

I want to thank you for your time and consideration in participating in this study.

Cindy Ziegler
Doctoral Candidate
Walden University

Appendix D: Round 1 Questions for Expert Panel

First Round of Questions for Mathematics Experts (for Delphi Study)

Round 1 of Questions

Dear Participant,

Congratulations! You have been accepted as an Expert member on the panel for this project study. Thank you for your willingness to participate.

You have been asked to answer these questions based upon your selection as an educational expert in applying teaching strategies that can be used with middle school math students. Each of the scenarios in the survey is based on one of the NCTM Standards for sixth through eighth grade students. From a computer of your choice and at a time of your convenience, please click on the survey link and provide your responses within 1 week. The survey should take less than 30 minutes of your time.

Thank you, Cindy Ziegler

* **Please type in your personal 2-digit alphanumeric code provided to you by Cindy Ziegler in the email sent to you with this survey link.**

NOTE:

On the following 5 pages, please give a detailed description of how you would facilitate student understanding/learning of the topic on that page using one or more instructional strategies. Please include exemplar problems or contexts that you would use as well as the instructional strategies you would employ and why.

Your answers are NOT restricted by the size of the box -- the box will expand if/as necessary to accommodate your response.

Next

First Round of Questions for Mathematics Experts (for Delphi Study)

Numbers and Operations

Numbers and Operations (Instructions)

Please describe the specific strategies you would use to support students as they learn to understand and use ratios and proportions to represent quantitative relationships. The following sample problem is one that students should be able to solve at a proficient level.

1. Numbers and Operations (Sample Problem):

"A car travels 140 miles on 10 gallons of fuel. How far can it go on a tankful of gas if the tank holds 15 gallons?"

* **1a. Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.**

* **1b. Please share exemplar or relevant problems/contexts.**

* **1c. Which instructional strategies would you identify as most helpful from your own experience?**

* **1d. Share your rationale about why/how these strategies work.**

Prev Next

First Round of Questions for Mathematics Experts (for Delphi Study)

Algebra

Algebra (Instructions)

Please describe the specific strategies you would use to support students as they learn use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships. The following sample problem is one that students should be able to solve at a proficient level.

2. Algebra (Sample Problem):

"ABC Phones sells monthly cell service for $0.50 per minute for the first 30 minutes but only $0.10 a minute for each minute after. Graph the rate of change for this plan."

* **2a. Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.**

* **2b. Please share exemplar or relevant problems/contexts.**

* **2c. Which instructional strategies would you identify as most helpful from your own experience?**

* **2d. Share your rationale about why/how these strategies work.**

Prev Next

First Round of Questions for Mathematics Experts (for Delphi Study)

Geometry

Geometry (Sample Instructions):

Please describe the specific strategies you would use to support students when solving problems involving scale factors, using ratio and proportion. The following sample problem is one that students should be able to solve at a proficient level.

3. Geometry (Sample Problem):

"List a triangle that is similar to one with measurements 4, 4, and 7. Draw the new model and explain how you knew it was similar to the original."

* 3a. Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.

* 3b. Please share exemplar or relevant problems/contexts.

* 3c. Which instructional strategies would you identify as most helpful from your own experience?

* 3d. Share your rationale about why/how these strategies work.

Prev Next

First Round of Questions for Mathematics Experts (for Delphi Study)

Measurement

Measurement (Instructions)

Please describe the specific strategies you would use to support students in coordinate geometry to represent and examine the properties of geometric shapes. The following sample problem is one that students should be able to solve at a proficient level.

4. Measurement (Sample Problem):

"Scale Factor: 1 inch = 300 miles.

If the distance from Denver, CO to Salina, UT is 1.5 inches on the map, how far is the distance between the two cities in actual miles?"

* **4a. Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.**

* **4b. Please share exemplar or relevant problems/contexts.**

* **4c. Which instructional strategies would you identify as most helpful from your own experience?**

* **4d. Share your rationale about why/how these strategies work.**

Prev Next

First Round of Questions for Mathematics Experts (for Delphi Study)

Data Analysis and Probability

Data Analysis and Probability (Instructions)

Please describe the specific strategies you would use to support students to find, use, and interpret measures of center and spread, including mean and interquartile range. The following sample problem is one that students should be able to solve at a proficient level.

5. Data Analysis and Probability (Sample Problem):

"Collect data from newspaper weather/temperature charts about the temperatures in selected cities within a region of the United States. Calculate central measures and determine which city is warmest. Analyze the data to make conjectures about the warmest city and determine if different central measures yield different results."

* 5a. Please provide a detailed description of what you would do to facilitate student understanding for this sample problem.

* 5b. Please share exemplar or relevant problems/contexts.

* 5c. Which instructional strategies would you identify as most helpful from your own experience?

* 5d. Share your rationale about why/how these strategies work.

Remember to click on the "Submit" button below to properly submit your survey.

Prev Submit

Appendix E: Round 2 Questions for Expert Panel

Second Round of Questions for Mathematics Experts (for Delphi Study)

Round 2 of Questions

17%

Dear Participant,

Thank you for your help with Round 1 of data collection.

Welcome to Round 2. In this round, you are asked to answer questions based upon your selection as an educational expert in applying teaching strategies that can be used with middle school math students. Each of the strategies below are strategies that you or other experts in the study suggested in Round 1.

From a computer of your choice and at a time of your convenience, please click on the survey link and provide your responses within 1 week of the date the survey was sent to you. The survey should take less than 60 minutes of your time.

Thank you,
Cindy Ziegler

*** Please type in your personal 2-digit alphanumeric code provided to you by Cindy Ziegler in the email sent to you with this survey link.**

NOTE:

On the following pages, please rate each strategy and explain your rationale for your rating for each strategy in the provided comment box under each strategy. Your answers are NOT restricted by the size of the box -- the box will expand if/as necessary to accommodate your response.

Next

Second Round of Questions for Mathematics Experts (for Delphi Study)

Numbers and Operations Strategies

33%

Numbers and Operations (Instructions)

Please rate the effectiveness of each strategy for teaching the provided Numbers and Operations concept and explain the rationale for your rating of each strategy. Each strategy requires a rating and a rationale.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Numbers and Operations concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Numbers and Operations concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Numbers and Operations concept.
4 = Effective. This strategy is effective to teach this Numbers and Operations concept.
5 = Very effective. This strategy is essential in teaching this Numbers and Operations concept.

1. Numbers and Operations (Sample Problem):

"A car travels 140 miles on 10 gallons of fuel. How far can it go on a tankful of gas if the tank holds 15 gallons?"

* **Numbers and Operations: Please rate the effectiveness of each strategy -- using the scale above -- and explain the rationale for your rating of each strategy (each strategy requires a rating and a rationale):**

	1	2	3	4	5
Demonstrate Real World Application	○	○	○	○	○
Rationale for Rating					
Use Small Group Collaboration and Discussion	○	○	○	○	○
Rationale for Rating					
Explore the Vocabulary	○	○	○	○	○
Rationale for Rating					

Provide a Template/Model	○	○	○	○	○

Rationale for Rating

Use Colors to Help Track Steps or Patterns	○	○	○	○	○

Rationale for Rating

Connect Learning to Similar Concepts (Scaffolding)	○	○	○	○	○

Rationale for Rating

Work Independently (Practice Alone)	○	○	○	○	○

Rationale for Rating

Provide Examples (Use Different Numbers to Solve Similar Problems)	○	○	○	○	○

Rationale for Rating

Use Graphic Organizers, Charts, and Tables	○	○	○	○	○

Rationale for Rating

Use Inquiry Learning (Student-Led Instruction)	○	○	○	○	○

Rationale for Rating

Provide Pictures and Visuals	○	○	○	○	○

Rationale for Rating

Prev Next

Second Round of Questions for Mathematics Experts (for Delphi Study)

Algebra Strategies

50%

Algebra (Instructions)

Please rate the effectiveness of each strategy for teaching the provided Algebra concept and explain the rationale for your rating of each strategy. Each strategy requires a rating and a rationale.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Algebra concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Algebra concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Algebra concept.
4 = Effective. This strategy is effective to teach this Algebra concept.
5 = Very effective. This strategy is essential in teaching this Algebra concept.

2. Algebra (Sample Problem):

"ABC Phones sells monthly cell service for $0.50 per minute for the first 30 minutes but only $0.10 a minute for each minute after. Graph the rate of change for this plan."

*** Algebra: Please rate the effectiveness of each strategy -- using the scale above -- and explain the rationale for your rating of each strategy (each strategy requires a rating and a rationale):**

	1	2	3	4	5
Demonstrate Real World Application	○	○	○	○	○
Rationale for Rating					
Use Small Group Collaboration and Discussion	○	○	○	○	○
Rationale for Rating					
Explore the Vocabulary	○	○	○	○	○
Rationale for Rating					

Provide a Template/Model

Rationale for Rating

Connect Learning to Similar Concepts (Scaffolding)

Rationale for Rating

Work Independently (Practice Alone)

Rationale for Rating

Use Graphic Organizers, Charts, and Tables

Rationale for Rating

Use Inquiry Learning (Student-Led Instruction)

Rationale for Rating

Provide Pictures and Visuals

Rationale for Rating

Prev Next

Second Round of Questions for Mathematics Experts (for Delphi Study)

Geometry Strategies

67%

Geometry (Instructions)

Please rate the effectiveness of each strategy for teaching the provided Geometry concept and explain the rationale for your rating of each strategy. Each strategy requires a rating and a rationale.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Geometry concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Geometry concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Geometry concept.
4 = Effective. This strategy is effective to teach this Geometry concept.
5 = Very effective. This strategy is essential in teaching this Geometry concept.

3. Geometry (Sample Problem):

"List a triangle that is similar to one with measurements 4, 4, and 7. Draw the new model and explain how you knew it was similar to the original."

*** Geometry: Please rate the effectiveness of each strategy -- using the scale above -- and explain the rationale for your rating of each strategy (each strategy requires a rating and a rationale):**

	1	2	3	4	5
Demonstrate Real World Application	○	○	○	○	○
Rationale for Rating					
Solve/Demonstrate Using Technology	○	○	○	○	○
Rationale for Rating					
Use Small Group Collaboration and Discussion	○	○	○	○	○
Rationale for Rating					

Explore the Vocabulary ○ ○ ○ ○ ○

Rationale for Rating

Connect Learning to Similar Concepts (Scaffolding) ○ ○ ○ ○ ○

Rationale for Rating

Use Graphic Organizers, Charts, and Tables ○ ○ ○ ○ ○

Rationale for Rating

Use Inquiry Learning (Student-Led Instruction) ○ ○ ○ ○ ○

Rationale for Rating

Provide Pictures and Visuals ○ ○ ○ ○ ○

Rationale for Rating

Prev Next

Second Round of Questions for Mathematics Experts (for Delphi Study)

Measurement Strategies

83%

Measurement (Instructions)

Please rate the effectiveness of each strategy for teaching the provided Measurement concept and explain the rationale for your rating of each strategy. Each strategy requires a rating and a rationale.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Measurement concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Measurement concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Measurement concept.
4 = Effective. This strategy is effective to teach this Measurement concept.
5 = Very effective. This strategy is essential in teaching this Measurement concept.

4. Measurement (Sample Problem):

"Scale Factor: 1 inch = 300 miles.

If the distance from Denver, CO to Salina, UT is 1.5 inches on the map, how far is the distance between the two cities in actual miles?"

* **Measurement: Please rate the effectiveness of each strategy -- using the scale above -- and explain the rationale for your rating of each strategy (each strategy requires a rating and a rationale):**

	1	2	3	4	5
Demonstrate Real World Application	○	○	○	○	○
Rationale for Rating					
Solve/Demonstrate Using Technology	○	○	○	○	○
Rationale for Rating					
Use Small Group Collaboration and Discussion	○	○	○	○	○
Rationale for Rating					

Provide a Template/Model	○	○	○	○	○

Rationale for Rating

Connect Learning to Similar Concepts (Scaffolding)	○	○	○	○	○

Rationale for Rating

Work Independently (Practice Alone)	○	○	○	○	○

Rationale for Rating

Use Graphic Organizers, Charts, and Tables	○	○	○	○	○

Rationale for Rating

Use Inquiry Learning (Student-Led Instruction)	○	○	○	○	○

Rationale for Rating

Provide Pictures and Visuals	○	○	○	○	○

Rationale for Rating

Prev Next

Second Round of Questions for Mathematics Experts (for Delphi Study)

Data Analysis and Probability Strategies

100%

Data Analysis and Probability (Instructions)

Please rate the effectiveness of each strategy for teaching the provided Data Analysis and Probability concept and explain the rationale for your rating of each strategy. Each strategy requires a rating and a rationale.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Data Analysis and Probability concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Data Analysis and Probability concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Data Analysis and Probability concept.
4 = Effective. This strategy is effective to teach this Data Analysis and Probability concept.
5 = Very effective. This strategy is essential in teaching this Data Analysis and Probability concept.

5. Data Analysis and Probability (Sample Problem):

"Collect data from newspaper weather/temperature charts about the temperatures in selected cities within a region of the United States. Calculate central measures and determine which city is warmest. Analyze the data to make conjectures about the warmest city and determine if different central measures yield different results."

*** Data Analysis and Probability: Please rate the effectiveness of each strategy -- using the scale above -- and explain the rationale for your rating of each strategy (each strategy requires a rating and a rationale):**

	1	2	3	4	5
Demonstrate Real World Application	○	○	○	○	○
Rationale for Rating					
Solve/Demonstrate Using Technology	○	○	○	○	○
Rationale for Rating					
Use Small Group Collaboration and Discussion	○	○	○	○	○
Rationale for Rating					

Explore the Vocabulary	○	○	○	○	○
Rationale for Rating					
Provide a Template/Model	○	○	○	○	○
Rationale for Rating					
Connect Learning to Similar Concepts (Scaffolding)	○	○	○	○	○
Rationale for Rating					
Work Independently (Practice Alone)	○	○	○	○	○
Rationale for Rating					
Provide Examples (Use Different Numbers to Solve Similar Problems)	○	○	○	○	○
Rationale for Rating					
Use Graphic Organizers, Charts, and Tables	○	○	○	○	○
Rationale for Rating					

Use Inquiry Learning (Student-Led Instruction)	○	○	○	○	○

Rationale for Rating

Provide Pictures and Visuals	○	○	○	○	○

Rationale for Rating

Remember to click on the "Submit" button below to properly submit your survey.

Prev Submit

Appendix F: Round 3 Questions for Expert Panel

Final Round of Questions for Mathematics Experts

Numbers and Operations Strategies

33%

Numbers and Operations (Instructions)

Please review the Round 2 Ratings and Results for each strategy, along with the comments from the members of the Expert Panel. Based on this review, please provide your FINAL rating of the effectiveness of each strategy for teaching the provided Numbers and Operations concept. Each strategy requires a final rating.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Numbers and Operations concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Numbers and Operations concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Numbers and Operations concept.
4 = Effective. This strategy is effective to teach this Numbers and Operations concept.
5 = Very effective. This strategy is essential in teaching this Numbers and Operations concept.

1. Numbers and Operations (Sample Problem):

"A car travels 140 miles on 10 gallons of fuel. How far can it go on a tankful of gas if the tank holds 15 gallons?"

STRATEGY: DEMONSTRATE REAL WORLD APPLICATION

Round 2 Ratings: 5, 5, 5, 5, 4, 3, 2
Round 2 Results: Mean = 4.14 / Median = 5 / Mode = 5

Comments 1-7:

1. The idea of rates is directly applicable to problems such as a the one listed above. Teaching this concept as a real world application allows students to directly connect to the concepts.

2. A real world application will help most students but they will still have trouble applying it to individual problems.

3. Absolutely, this problem links to a very real world problem. Students would be able to connect to the concepts.

4. Helpful for buy in but not helpful in solving the problem.

5. Students learn and remember topic more when a concept is related to their real world, especially when in a topic such as cars and traveling.

6. Numbers and Operations is a part of every day life, the practice of these skills using real world applications should enhance the skill transfer process for students.

7. I think that making that real world connect makes it even more applicable to students. They can relate to not wanting to run out of gas. Setting it up in a real world situation make the numbers have meaning, more than just random numbers on a page.

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 5, 5, 4, 4, 4, 4, 4
Round 2 Results: Mean = 4.29 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. Any time something can be connected to previous learning it makes it more real.

3. I definitely use scaffolding daily for everything. I love to tie all my lessons back to previous knowledge if possible.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Students learn and remember topic more when a concept is related to their real world, especially when in a topic such as cars and traveling.

6. Numbers and Operations is a part of every day life, the practice of these skills using real world applications should enhance the skill transfer process for students.

7. I think that making that real world connect makes it even more applicable to students. They can relate to not wanting to run out of gas. Setting it up in a real world situation make the numbers have meaning, more than just random numbers on a page.

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 5, 5, 4, 4, 4, 4, 4
Round 2 Results: Mean = 4.29 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. Any time something can be connected to previous learning it makes it more real.

3. I definitely use scaffolding daily for everything. I love to tie all my lessons back to previous knowledge if possible.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. This is related to making that connection with what they already know and real life.

6. Connecting to similar concepts is important, making connections often helps understanding "stick" and not be forgotten.

7. I think the more you can connect math to similar concepts, the easier the brain can transfer information from one place to another. This is especially true with Number Sense. You can work with numbers in a variety of ways. The more you can connect the ways to each other, the more your brain will retain those concepts.

	1	2	3	4	5
CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)	○	○	○	○	○

STRATEGY: USE SMALL GROUP COLLABORATION AND DISCUSSION

Round 2 Ratings: 5, 5, 4, 4, 4, 3, 3
Round 2 Results: Mean = 4.00 / Median = 4 / Mode = 4

Comments 1-7:

1. Small group collaboration and discussion allows for social learning in addition to requiring higher order thinking skills.

2. By discussing and working through problems together, the students will create their own strategies and be able to take ownership of it.

3. Small groups and discussion would be ideal for solving this. Let students talk about what they think should be done to solve it. Do trial and error and see if they can get an answer that makes sense.

4. Students may be able to talk it through or may just confuse each other more. Allows for practice of academic language and help each other.

5. Group discussion among students is helpful to gather more information or techniques they may not have thought of on their own.

6. Students need to learn how to collaborate to be college and career ready, any skill or concept would be enhanced using collaborative strategies.

7. I always like to give the students a chance to work together and come up with their on theory of what could work in this problem. I think as they hypothesize, and try out different methods, they really learn how to work with numbers in a flexible way.

	1	2	3	4	5
USE SMALL GROUP COLLABORATION AND DISCUSSION	○	○	○	○	○

*

STRATEGY: PROVIDE EXAMPLES (Use different numbers to solve similar problems)

Round 2 Ratings: 5, 5, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.86 / Median = 4 / Mode = 4

Comments 1-7:

1. Examples are good, but the concept of a "rate" should not be reduced to plugging in numbers if possible.

2. Shows students what to do but not why necessarily.

3. YES! I love this and I do this daily. I try to practice at least 1-2 examples of each kind of problem they will encounter.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. As long as you don't begin by saying "this is how you do it" and then have students simply do the problem without getting the understanding. This is important but maybe after some explanation and discovery in groups.

6. Modeling is always useful, particularly when scaffolding.

7. I like this step especially after the initial instruction. Now that we have learned it, let's see if we can apply this to a new problem. Does it work the same? The more type of those questions that are asked, the more you can solidify your understanding as well.

	1	2	3	4	5
PROVIDE EXAMPLES (Use different numbers to solve similar problems)	○	○	○	○	○

*

STRATEGY: USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES

Round 2 Ratings: 4, 4, 4, 4, 3, 2, 2
Round 2 Results: Mean = 3.29 / Median = 4 / Mode = 4

Comments 1-7:

1. In this case, specifically using the graph of the rate (depending on the student level), will connect this idea with slope.

2. A table works very nicely for a rate problem.

3. For some problems this is great, for the problem above, no I wouldn't use this.

4. This would allow students to organize the information and extrapolate a formula or pattern.

5. Not really needed for this problem.

6. Always good for scaffolding learning and understanding.

7. I think these can be good or bad. They can help break big problems down into manageable steps, however, they also can get in the way of flexible thinking. I think Graphic Organizers can help after you have settled on a specific task or procedure, but if it is the only instruction being used, then it can get in the way of deeper learning.

	1	2	3	4	5
USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES	○	○	○	○	○

STRATEGY: PROVIDE PICTURES AND VISUALS

Round 2 Ratings: 5, 4, 4, 4, 3, 2, 1
Round 2 Results: Mean = 3.29 / Median = 4 / Mode = 4

Comments 1-7:

1. Providing pictures and visuals accounts for multiple intelligences, provided they are directly related to the concept.

2. Pictures for numbers in the hundreds is not very realistic.

3. I like the idea, but not for this problem.

4. This allows students to visualize the problem and figure out steps to problem solving.

5. Not really needed here.

6. This helps students examine and use different ways to manipulate skills and show what they know.

7. When in doubt, draw it out! I love having the students give the question meaning by drawing it out and making sense of what the question is asking is always an effective strategy in helping.

	1	2	3	4	5
PROVIDE PICTURES AND VISUALS	○	○	○	○	○

*

STRATEGY: WORK INDEPENDENTLY (Practice Alone)

Round 2 Ratings: 5, 4, 4, 3, 3, 2, 2
Round 2 Results: Mean = 3.29 / Median = 3 / Mode = 2, 3, 4

Comments 1-7:

1. Independent practice allows students to evaluate their own learning. However, this should only be used after a set of activities reinforcing the concept. Essentially, it is a double check for learning.

2. This assumes that the students have had sufficient instruction and have the confidence to tackle the problem.

3. I like to see students work independently, but not right away. I like to model and practice a few times first, then send them out to try on their own.

4. Only if I wanted to see who knew this and who did not. Then I would provide extra support to those who needed it.

5. This seems important and effective with any problems in math to make sure student gets it on his own to progress.

6. This is important and necessary for final demonstrations of mastery... but could be distracting if the only practice.

7. If a student doesn't understand one question, having them do 20 more of the same type of problems isn't going to help them understand any more. I think once they understand the concept, independent practice can help solidify their understanding, but without instruction first, it doesn't not help them learn new skills.

	1	2	3	4	5
WORK INDEPENDENTLY (Practice Alone)	○	○	○	○	○

*

STRATEGY: USE INQUIRY LEARNING (Student-led instruction)

Round 2 Ratings: 4, 4, 3, 3, 3, 3, 2
Round 2 Results: Mean = 3.14 / Median = 3 / Mode = 3

Comments 1-7:

1. Although I am almost always a fan of student-led instruction, in this case, practical experience has taught me that students often find this concept confusing when approached this way.

2. I don't really know enough about this to know how effective it would be.

3. I might use this. It depends on where I am in a concept. If I'm teaching it for the third day--YES--I would use this. If it's the first day, nope, I wouldn't do that. Too many students get really upset when they get things wrong and i would prefer to set them up for success.

4. Works well if students have an understanding of how to approach the problem.

5. Perhaps this could be used but not imperative.

6. I really like this concept, sometimes students have to be "trained" to practice inquiry.

7. I think number sense is the best place for inquiry based learning, because students can really break numbers, down, apart, and then put them together in a way that works for them. I would definitely use this strategy in teaching numbers sense.

	1	2	3	4	5
USE INQUIRY LEARNING (Student-led instruction)	○	○	○	○	○

STRATEGY: PROVIDE A TEMPLATE/MODEL

Round 2 Ratings: 4, 4, 3, 3, 3, 2, 2
Round 2 Results: Mean = 3.00 / Median = 3 / Mode = 3

Comments 1-7:

1. If you utilize the idea of the word "per" as a fraction bar, this becomes a type of model. However, teaching these types of problems using just a template that students plug numbers into does not allow for an understanding of rates that will be utilized in most advanced mathematics.

2. Students will still need to be shown how to use the template and it is just a set of rules to them.

3. You could use a model, but this problem is not ideal for that. I would not use this option when teaching this problem.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Don't think this is needed here.

6. Templates are always useful, particularly when scaffolding. I would just be careful not to allow students to become over-dependent on templates for mastery.

7. Models are always good, but I don't think that alone, it will extremely effective. If you layer this model with other approaches you can really help the students to dig deeper.

	1	2	3	4	5
PROVIDE A TEMPLATE/MODEL	○	○	○	○	○

*

STRATEGY: USE COLORS TO HELP TRACK STEPS OR PATTERNS

Round 2 Ratings: 4, 3, 3, 3, 2, 1, 1
Round 2 Results: Mean = 2.43 / Median = 3 / Mode = 3

Comments 1-7:

1. While using colors to track steps or patterns is useful in some areas of instruction, in this case, it will move students away from the larger concept of rates.

2. I don't know what this means.

3. I like the idea of using colors and patterns, but the reality is, I would not teach it this way. I would use small groups or scaffolding.

4. Seems too basic and could be confusing.

5. Maybe to high light the units in the numerator and denominator in the proportion you are using to understand being consistent when setting up the proportion. Not really needed in this problem.

6. Visual cues are helpful and can help motivate students to become responsible for their learning.

7. Again, this is a great strategy for helping students organize the information and understand the question, but on it's own, this strategy will not teach number sense to children.

	1	2	3	4	5
USE COLORS TO HELP TRACK STEPS OR PATTERNS	○	○	○	○	○

*

STRATEGY: EXPLORE THE VOCABULARY

Round 2 Ratings: 4, 3, 3, 2, 2, 2, 1
Round 2 Results: Mean = 2.43 / Median = 2 / Mode = 2

Comments 1-7:

1. Although the vocabulary words of "rate" and the idea of "per" being the fraction bar is appropriate to this content, it will not directly lend itself to an understanding of the content.

2. Vocabulary is not a tool that would help solve this problem. Students can determine methods without the right terms.

3. This problem really doesn't have lots of math vocabulary. I suppose you could interject it, but it's not ideal.

4. The vocabulary was not that challenging.

5. Unless there are words that are new to the student which doesn't seem needed here.

6. Academic vocabulary is important, but not essential in understanding numbers and operations.

7. I think that this is an important part, but it will not get the students to the right answer on it's own. Looking for those keywords to help identify the operation/s needed to solve this problem is a great first step. But even if they can identify what to do, it doesn't mean they can do it just yet.

	1	2	3	4	5
EXPLORE THE VOCABULARY	○	○	○	○	○

Prev Next

Final Round of Questions for Mathematics Experts

Algebra Strategies

50%

Algebra (Instructions)

Please review the Round 2 Ratings and Results for each strategy, along with the comments from the members of the Expert Panel. Based on this review, please provide your FINAL rating of the effectiveness of each strategy for teaching the provided Algebra concept. Each strategy requires a final rating.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Algebra concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Algebra concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Algebra concept.
4 = Effective. This strategy is effective to teach this Algebra concept.
5 = Very effective. This strategy is essential in teaching this Algebra concept.

2. Algebra (Sample Problem):

"ABC Phones sells monthly cell service for $0.50 per minute for the first 30 minutes but only $0.10 a minute for each minute after. Graph the rate of change for this plan."

*

STRATEGY: USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES

Round 2 Ratings: 5, 5, 5, 5, 4, 4, 3
Round 2 Results: Mean = 4.43 / Median = 5 / Mode = 5

Comments 1-7:

1. Graphing the concept of rate starting at a location other than zero provides a clear visual of the connection between rates, linear graphs and linear equations.

2. Graphing, linear models, and tables really help students see the relationship between the algebraic formula and the problem they are analyzing.

3. YES! I would use charts and tables and graphs and lines and whatever else I could think of to show students how this problem works.

4. This would allow students to organize the information and extrapolate a formula or pattern.

5. These visuals are always helpful in this type of problem and needed here for looking at rate of change.

6. Important for scaffolding and building understanding.

7. Can be helpful in organizing information and breaking things down into steps, but it can limit understanding and flexibility with numbers.

	1	2	3	4	5
USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES	○	○	○	○	○

*

STRATEGY: PROVIDE PICTURES AND VISUALS

Round 2 Ratings: 5, 5, 5, 4, 4, 4, 2
Round 2 Results: Mean = 4.14 / Median = 4 / Mode = 4, 5

Comments 1-7:

1. Graphing this problem is a clear way to demonstrate the concept of rate.

2. A visual in a graph form is helpful but not otherwise.

3. Visuals is the key to this problem...showing them what rate of change look like is very important.

4. This allows students to visualize the problem and figure out steps to problem solving.

5. Graphing is very effective - so this could be the visual.

6. Important for building understanding and transferability.

7. When in doubt, draw it out.

	1	2	3	4	5
PROVIDE PICTURES AND VISUALS	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 5, 5, 4, 4, 4, 4, 3
Round 2 Results: Mean = 4.14 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. Will help see students see the progression but is still mostly teacher led so the students do not take ownership.

3. I would definitely scaffold beginning with the basic concept of figuring out how much the plan would cost for just 30 minutes.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Best to relate to what they know about phones now and see what their background knowledge is first to see where they are now. Do you have a phone? Do you know how your bill works now, are you paying or do your parents pay. If you were paying, how would this work, etc.

6. Important for building and sustaining knowledge.

7. Again, the more you can connect Algebra to real life the better. Is there another type of problem that follows this format that is applicable to students, connect away :)

	1	2	3	4	5
CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)	○	○	○	○	○

STRATEGY: USE SMALL GROUP COLLABORATION AND DISCUSSION

Round 2 Ratings: 5, 4, 4, 4, 4, 4, 3
Round 2 Results: Mean = 4.00 / Median = 4 / Mode = 4

Comments 1-7:

1. Small group collaboration and discussion provides an opportunity to expand learning using the idea of social learning.

2. The students will own their work when working together and will have a good idea of how to use it in the future.

3. I always like to use this approach when possible. I like the idea of guess and check and brainstorming on what they think should be done.

4. Students may be able to talk it through or may just confuse each other more. Allows for practice of academic language and help each other.

5. Always helpful to get others ideas

6. Equally important skill that reinforces content mastery.

7. This is a problem that the students can explore different ways of trying things out. It think ti would be an interesting starting point for the students to work together to try and solve the answer.

	1	2	3	4	5
USE SMALL GROUP COLLABORATION AND DISCUSSION	○	○	○	○	○

STRATEGY: DEMONSTRATE REAL WORLD APPLICATION

Round 2 Ratings: 5, 5, 5, 4, 4, 2, 2
Round 2 Results: Mean = 3.86 / Median = 4 / Mode = 5

Comments 1-7:

1. Rates with a starting point besides zero provide an excellent opportunity to connect with the real world application of business processes.

2. The problem is real world so demonstrating it won't help students solve it.

3. Yes, this is a great problem for showing real world application! Students would be able to relate.

4. Helpful for buy in but not helpful in solving the problem.

5. This is a real life problem and can easily relate to real life. Makes the learning more exciting and the kids more motivated.

6. Important for application to real world as an adult.

7. Part of the challenge of Algebra is learning how to put examples into "Algebra form". I think that many students could solve it by not using algebra at all :) The more you can relate this to a real life example that students care about, the more they will want to make that connection into "Algebra".

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: PROVIDE A TEMPLATE/MODEL

Round 2 Ratings: 5, 4, 4, 4, 3, 2, 2
Round 2 Results: Mean = 3.43 / Median = 4 / Mode = 4

Comments 1-7:

1. Relating the idea of rate to the concept of y= mx+b is an effective way to approach this idea.

2. Not really sure how this would apply to this problem.

3. Modeling here would be ideal: making sure students see that rate of change can be put into a graph and explored from there.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Thinking graphing and charts are more helpful in this problem for a visual.

6. Effective, but could become a crutch if not "taken away".

7. I think making a model of this cell phone plan is an important part of understanding exactly what this question is asking. But again, on it's own, it could become a crutch so the students just use the model instead of really making sense of the problem. Again, a strategy that could be used, but on it's own it is still not enough.

	1	2	3	4	5
PROVIDE A TEMPLATE/MODEL	○	○	○	○	○

*

STRATEGY: USE INQUIRY LEARNING (Student-led instruction)

Round 2 Ratings: 4, 4, 3, 3, 3, 3, 3
Round 2 Results: Mean = 3.29 / Median = 3 / Mode = 3

Comments 1-7:

1. Although I usually support student-led instruction, in this case, students tend to develop incorrect assumptions with this instructional method and concept.

2. Not very familiar with this.

3. Not ideal for this type of problem. I believe that would just led to more misconceptions.

4. Works well if students have an understanding of how to approach the problem.

5. Is helpful but not too early in the lesson.

6. Important for encouraging and practicing creativity.

7. I think I would worry about turning the kids loose completely with this problem. I think there are excellent collaboration and brainstorming here, but I provide a little more guidance if possible.

	1	2	3	4	5
USE INQUIRY LEARNING (Student-led instruction)	○	○	○	○	○

STRATEGY: WORK INDEPENDENTLY (Practice Alone)

Round 2 Ratings: 4, 4, 3, 3, 3, 2, 2
Round 2 Results: Mean = 3.00 / Median = 3 / Mode = 3

Comments 1-7:

1. Independent practice should be completed following alternative forms of instruction and practice as a way for students to self-evaluate their learning.

2. This is necessary but should be after some of the other strategies.

3. I probably would not use this strictly because rate of change problems tend to be difficult for students. I would prefer a group approach.

4. Only if I wanted to see who knew this and who did not. Then I would provide extra support to those who needed it.

5. Seems like this problem is best for groups to understand and problem solve together. So they can feed off each other's ideas as they work.

6. Important to demonstrate mastery.

7. On it's own, if you don't understand 1 problem, you aren't going to understand 20 more problems just like it, unless you have some good instruction on the front end.

	1	2	3	4	5
WORK INDEPENDENTLY (Practice Alone)	○	○	○	○	○

*

STRATEGY: EXPLORE THE VOCABULARY

Round 2 Ratings: 4, 4, 3, 3, 2, 2, 1
Round 2 Results: Mean = 2.71 / Median = 3 / Mode = 2, 3, 4

Comments 1-7:

1. While the vocabulary words "rate" and the idea of "per" as a fraction bar are important, they are not necessarily an effective method for students to understanding the overall concept of rate.

2. The vocabulary is abstract and does not help solve the problem much

3. Not a bad problem for vocabulary, but not the best. Rate of change could be discussed after exploring the problem.

4. The vocabulary was not that challenging.

5. Don't think any of the words are needed to explore here.

6. Important but not essential in understanding algebra.

7. There isn't a lot of vocabulary here. You could talk about where to use the variable, and what type of problem it is, but that is about it. On it's own, I don't think that only focusing on the vocabulary would help the students solve this. But it would be an important strategy to use during your instruction.

	1	2	3	4	5
EXPLORE THE VOCABULARY	○	○	○	○	○

Prev Next

Final Round of Questions for Mathematics Experts

Geometry Strategies

67%

Geometry (Instructions)

Please review the Round 2 Ratings and Results for each strategy, along with the comments from the members of the Expert Panel. Based on this review, please provide your FINAL rating of the effectiveness of each strategy for teaching the provided Geometry concept. Each strategy requires a final rating.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Geometry concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Geometry concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Geometry concept.
4 = Effective. This strategy is effective to teach this Geometry concept.
5 = Very effective. This strategy is essential in teaching this Geometry concept.

3. Geometry (Sample Problem):

"List a triangle that is similar to one with measurements 4, 4, and 7. Draw the new model and explain how you knew it was similar to the original."

STRATEGY: PROVIDE PICTURES AND VISUALS

Round 2 Ratings: 5, 5, 5, 5, 5, 4, 4
Round 2 Results: Mean = 4.71 / Median = 5 / Mode = 5

Comments 1-7:

1. This concept should not be taught without visuals!

2. Pictures and visuals are extremely important when trying to grasp abstract concepts and make them realistic as is often the case in geometry.

3. Absolutely! Pictures is the best way to show similarity and non-similarity.

4. This allows students to visualize the problem and figure out steps to problem solving.

5. Needed in this geometry example to start for the different triangles, to see the side measurements and even angles so a similar triangle can be seen. But when more examples are added, a chart is helpful with the numbers and their relationships shown.

6. Essential for demonstrating understanding, showing what they know in more than one way.

7. This is an especially good problem to draw out.

	1	2	3	4	5
PROVIDE PICTURES AND VISUALS	○	○	○	○	○

*

STRATEGY: USE INQUIRY LEARNING (Student-led instruction)

Round 2 Ratings: 5, 5, 5, 4, 3, 3, 2
Round 2 Results: Mean = 3.86 / Median = 4 / Mode = 5

Comments 1-7:

1. This concept lends itself well to student-led instruction by giving the students a strict line of inquiry based activities that lead to the concept of similar triangles.

2. Don't know much about this so it is difficult to rate.

3. YES! Most students should be familiar with the word similar and be able to reason out what the question is asking. This is an ideal problem for student teachers.

4. Allows for practice of academic language and for students to share ideas.

5. Not sure too needed here.

6. Essential for establishing and practicing creativity.

7. I think that students making hypothesis and trying them out would be an effective way to really have them make understanding and connection with this topic.

	1	2	3	4	5
USE INQUIRY LEARNING (Student-led instruction)	○	○	○	○	○

*

STRATEGY: EXPLORE THE VOCABULARY

Round 2 Ratings: 5, 4, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 4

Comments 1-7:

1. The vocabulary word "similar" is at the heart of this concept.

2. Vocabulary is very important and helpful in geometry - the terms often tell all that is needed to solve a problem.

3. Not a bad problem for vocabulary, but ideally they would be able to link what they know about similar and use it in geometry.

4. The vocabulary was not that challenging.

5. In Geometry vocabulary is extremely important.

6. Important but not essential in mastering the concept.

7. This problem has some important vocabulary. I think that exploring the vocabulary is and extremely important first step in understanding what this problem is even asking.

	1	2	3	4	5
EXPLORE THE VOCABULARY	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 4, 4, 4, 4, 4, 3, 3
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. This can be a valid technique.

3. This problem would be hard to scaffold. There is not much prior knowledge you could tap into.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Always helpful but not as effective as some of the other techniques for this type of problem.

6. Important for building knowledge.

7. Again, the more connections, the stronger the brain connections.

	1	2	3	4	5
CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)	○	○	○	○	○

*

STRATEGY: USE SMALL GROUP COLLABORATION AND DISCUSSION

Round 2 Ratings: 5, 4, 4, 4, 3, 3, 3
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 3, 4

Comments 1-7:

1. Small group collaboration and discussion can be used to expand this concept by applying it to varying student interests.

2. Collaboration is good but it does not provide all the tools necessary for the students to tackle this problem.

3. Groups could be used but in this kind of focused problem, i would prefer to use individuals.

4. Allows for practice of academic language and for students to share ideas.

5. Groups are always helpful for adding new ideas and solutions.

6. Essential skill to be college and career ready.

7. This is a fun one to turn over to groups and let them come up with a way to solve the problem. Let them try it out.

	1	2	3	4	5
USE SMALL GROUP COLLABORATION AND DISCUSSION	○	○	○	○	○

STRATEGY: SOLVE/DEMONSTRATE USING TECHNOLOGY

Round 2 Ratings: 4, 4, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.57 / Median = 4 / Mode = 4

Comments 1-7:

1. Technology provides an excellent opportunity for students to experiment with this concept, addressing visual and kinetic learning styles.

2. A computer allows students to explore the relationship between similar triangles without having to do the cumbersome drawing. They can discover the principles more readily.

3. I cannot see where technology would help with this problem at all. I would prefer to see students draw this out.

4. Allows for real world problem solving. Connects technology to math.

5. In today's world so many Geometry apps (sketchpad, etc) are available and help tremendously with gaining even more understanding than ever before. Large quantities of similar triangles can be examined (stretched, reduced, etc) Technology should be used whenever possible to enhance this type of problem, saving time and making it even more exciting to learn.

6. Important skill to be mastered as an adult.

7. This is effective for getting the right answer, but not always for increasing mathematical understanding. I think it is part of the answer, but not the whole answer on it's own.

	1	2	3	4	5
SOLVE/DEMONSTRATE USING TECHNOLOGY	○	○	○	○	○

*

STRATEGY: DEMONSTRATE REAL WORLD APPLICATION

Round 2 Ratings: 5, 5, 4, 4, 3, 2, 2
Round 2 Results: Mean = 3.57 / Median = 4 / Mode = 2, 4, 5

Comments 1-7:

1. This idea can and should be tied to real world application such as a construction. However, it should first be addressed using alternative instructional methods.

2. In Geometry, showing how something relates to the real world allows students to get a handle on abstract concepts. A scale model would be a good example for this problem.

3. This problem does not link to real world application at all and I'm not sure how this concept could be linked.

4. Helpful for buy in but not helpful in solving the problem.

5. Very helpful for this type of problem and not done often enough. When there is real life application, it makes more sense as to why they are learning about similarity and how it is used.

6. Essential for transferability to the real world as an adult.

7. This is an excellent example of "why should I care about this". I think if you can make that connection to a real life example and get that student "buy in" that the students should care, and this is why they should care, that is when real learning can take place.

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES

Round 2 Ratings: 4, 4, 4, 4, 3, 3, 2
Round 2 Results: Mean = 3.43 / Median = 4 / Mode = 4

Comments 1-7:

1. This concept can be taught and understood easily thorough the progress of a table of changing values.

2. Graphic organizers and tables can help, but hands on manipulation works better or understanding the terms.

3. I cannot think of a way I would use charts or graphs on this, except maybe to show it on the coordinate plane.

4. This would allow students to organize the information and extrapolate a formula or pattern.

5. A table of different triangle measurement and the relationship among the sides (ratios) can more easily be examined when placed in a chart.

6. Important for building understanding, but needs to be removed to demonstrate mastery.

7. As a stand alone strategy, this one is not super effective.

	1	2	3	4	5
USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES	○	○	○	○	○

Prev Next

Final Round of Questions for Mathematics Experts

Measurement Strategies

83%

Measurement (Instructions)

Please review the Round 2 Ratings and Results for each strategy, along with the comments from the members of the Expert Panel. Based on this review, please provide your FINAL rating of the effectiveness of each strategy for teaching the provided Measurement concept. Each strategy requires a final rating.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Measurement concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Measurement concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Measurement concept.
4 = Effective. This strategy is effective to teach this Measurement concept.
5 = Very effective. This strategy is essential in teaching this Measurement concept.

4. Measurement (Sample Problem):

"Scale Factor: 1 inch = 300 miles.

If the distance from Denver, CO to Salina, UT is 1.5 inches on the map, how far is the distance between the two cities in actual miles?"

*

STRATEGY: PROVIDE PICTURES AND VISUALS

Round 2 Ratings: 5, 5, 5, 4, 4, 4, 2
Round 2 Results: Mean = 4.14 / Median = 4 / Mode = 4, 5

Comments 1-7:

1. This concept should not be taught without pictures or visuals.

2. The picture is helpful, as in this case the map, but it does not usually give enough for the students to know what to do next.

3. YES! Show the maps, show the scales, make up other examples using pictures of real life things.

4. This allows students to visualize the problem and figure out steps to problem solving.

5. Need a map for this problem to show how it is used.

6. Important for showing what they are thinking.

7. When in doubt, draw it out.

	1	2	3	4	5
PROVIDE PICTURES AND VISUALS	○	○	○	○	○

*

STRATEGY: USE SMALL GROUP COLLABORATION AND DISCUSSION

Round 2 Ratings: 5, 5, 4, 4, 3, 3, 3
Round 2 Results: Mean = 3.86 / Median = 4 / Mode = 3

Comments 1-7:

1. Social learning is an effective way to reinforce concepts. However, based on experience, it should be the second activity after a large group focused activity to clarify expectations.

2. Working together brings out good ideas and personal ownership of the work.

3. Yes, brainstorming about how to solve would be ideal.

4. Students may be able to talk it through or may just confuse each other more. Allows for practice of academic language and help each other.

5. Always a good idea for collaborating and discussing - may be more helpful for solving here for students who struggle.

6. Essential skill for adults ... college and career.

7. Always a good solution.

	1	2	3	4	5
USE SMALL GROUP COLLABORATION AND DISCUSSION	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 5, 4, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. This is a good place to start and should be combined with other strategies.

3. Yes, you could scaffold prior to this lesson, but I would scaffold afterwards. I would lead into cross multiplication after this.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Not sure how to be used here.

6. Important to be able to explain their thinking.

7. In this case, I think a model would be an excellent tool to help instruction. It may not be the only tool, but one that could definitely help.

	1	2	3	4	5
CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)	○	○	○	○	○

*

STRATEGY: WORK INDEPENDENTLY (Practice Alone)

Round 2 Ratings: 5, 4, 4, 4, 3, 2, 2
Round 2 Results: Mean = 3.43 / Median = 4 / Mode = 4

Comments 1-7:

1. Scale factors are a concept that students seem to need to do in order to understand. Independent practice allows for this opportunity.

2. This is helpful to build individual confidence but should be done after another technique.

3. Yes, I think giving students the option to do this alone would be nice if you brought everyone back together and discussed options for solving.

4. Only if I wanted to see who knew this and who did not. Then I would provide extra support to those who needed it.

5. Once they have worked in groups, perhaps they can try one on their own to make sure they get it.

6. Essential for mastery.

7. If that is all they are going to get...probably not super effective.

	1	2	3	4	5
WORK INDEPENDENTLY (Practice Alone)	○	○	○	○	○

STRATEGY: USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES

Round 2 Ratings: 4, 4, 4, 4, 3, 3, 2
Round 2 Results: Mean = 3.43 / Median = 4 / Mode = 4

Comments 1-7:

1. For this concept, students end up plugging in numbers without understanding what they mean.

2. Tables and charts are very helpful to organize measurement data and to show the relationships.

3. Using maps would be an obvious choice and a good one.

4. This would allow students to organize the information and extrapolate a formula or pattern.

5. May help to show a chart of the real size numbers vs the map size numbers.

6. Important for working with and learning about concepts and skills.

7. A ratio table might be just the ticket for this one. Definitely part of the process.

	1	2	3	4	5
USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES	○	○	○	○	○

*

STRATEGY: DEMONSTRATE REAL WORLD APPLICATION

Round 2 Ratings: 5, 5, 4, 4, 3, 2, 2
Round 2 Results: Mean = 3.57 / Median = 4 / Mode = 2, 4, 5

Comments 1-7:

1. Measurement should always be taught in the context of real world application, especially scales.

2. Demonstrating real world application helps the students understand why it is important but does not take them all the way to being able to do it.

3. This USED to be real world. Sadly, it's not really, not anymore, not with smart phones. But you could reference the days of yore...

4. Helpful for buy in but not helpful in solving the problem.

5. Always important.

6. Essential for life long learning and application.

7. Alone, this will not solve the problem for you, but he real world application helps to generate a concrete idea of what the problem is even asking.

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: USE INQUIRY LEARNING (Student-led instruction)

Round 2 Ratings: 5, 4, 4, 3, 3, 3, 2
Round 2 Results: Mean = 3.43 / Median = 3 / Mode = 3

Comments 1-7:

1. Student-led instruction can be highly effective in for this concept, provided it includes a high level of scaffolding.

2. not familiar with this so difficult to rate.

3. I'm not sure students read maps much anymore, so I probably would not allow students to teach this the first time around.

4. Works well if students have an understanding of how to approach the problem.

5. Not sure this is needed here.

6. Essential for creativity.

7. I think there is a lot to be said for letting the students make sense of this kind of problem. Have them make a hypothesis, and see if it works. Again, part of the process.

	1	2	3	4	5
USE INQUIRY LEARNING (Student-led instruction)	○	○	○	○	○

*

STRATEGY: SOLVE/DEMONSTRATE USING TECHNOLOGY

Round 2 Ratings: 5, 4, 4, 4, 3, 2, 1
Round 2 Results: Mean = 3.29 / Median = 4 / Mode = 4

Comments 1-7:

1. This type of problem can be demonstrated clearly using the zoom function on a map tool.

2. I do not know what technology would help without becoming a crutch for the students.

3. You could definitely bring technology into this lesson, talk about real maps versus Google maps and how Google creates their estimates. To actually solve the problem, I would not use technology.

4. Allows for real world problem solving. Connects technology to math.

5. Not really needed here.

6. Important to be able to do, but not essential in mastering this skill.

7. On it's own, not super effective. It doesn't help generate understanding. However, it is a great tool to find the answer.

	1	2	3	4	5
SOLVE/DEMONSTRATE USING TECHNOLOGY	○	○	○	○	○

*

STRATEGY: PROVIDE A TEMPLATE/MODEL

Round 2 Ratings: 5, 4, 4, 4, 2, 2, 2
Round 2 Results: Mean = 3.29 / Median = 4 / Mode = 2, 4

Comments 1-7:

1. While a ratio can be used as a template in this case, students do not grasp the concept of scale factors by filling in the parts of the ratio.

2. A template is a lot like a formula and is something that has to be remembered and is not always understood.

3. Yes! Showing students real maps with real scale factors would be fantastic! Having ruler for them to attempt to measure is even better!

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. A map is needed.

6. Important to be able to explain their thinking.

7. In this case, I think a model would be an excellent tool to help instruction. It may not be the only tool, but one that could definitely help.

	1	2	3	4	5
PROVIDE A TEMPLATE/MODEL	○	○	○	○	○

Prev Next

Final Round of Questions for Mathematics Experts

Data Analysis and Probability Strategies

100%

Data Analysis and Probability (Instructions)

Please review the Round 2 Ratings and Results for each strategy, along with the comments from the members of the Expert Panel. Based on this review, please provide your FINAL rating of the effectiveness of each strategy for teaching the provided Data Analysis and Probability concept. Each strategy requires a final rating.

Use the following scale when rating each strategy:

1 = Not effective. This strategy is not very effective to teach this Data Analysis and Probability concept.
2 = Minimally effective. This strategy is only minimally effective to teach this Data Analysis and Probability concept.
3 = Somewhat effective. This strategy is somewhat effective to teach this Data Analysis and Probability concept.
4 = Effective. This strategy is effective to teach this Data Analysis and Probability concept.
5 = Very effective. This strategy is essential in teaching this Data Analysis and Probability concept.

5. Data Analysis and Probability (Sample Problem):

"Collect data from newspaper weather/temperature charts about the temperatures in selected cities within a region of the United States. Calculate central measures and determine which city is warmest. Analyze the data to make conjectures about the warmest city and determine if different central measures yield different results."

*

STRATEGY: USE SMALL GROUP COLLABORATION AND DISCUSSION

Round 2 Ratings: 5, 5, 5, 5, 4, 4, 3
Round 2 Results: Mean = 4.43 / Median = 5 / Mode = 5

Comments 1-7:

1. With classes containing students from a variety of areas, this provides an opportunity for students to take ownership of this concept through their own data.

2. I always think this method works no matter what you are studying!

3. Small groups is exactly how i would teach this. They would gather data in their group and come up with a solution to present to the class.

4. Students may be able to talk it through or may just confuse each other more. Allows for practice of academic language and help each other.

5. Groups are very helpful for this type of problem when it involves so many concepts. Students need to feel like they have that support because at first it may seem more difficult.

6. Essential skill for real life application as an adult.

7. Always a great idea.

	1	2	3	4	5
USE SMALL GROUP COLLABORATION AND DISCUSSION	○	○	○	○	○

*

STRATEGY: DEMONSTRATE REAL WORLD APPLICATION

Round 2 Ratings: 5, 5, 5, 5, 4, 4, 2
Round 2 Results: Mean = 4.29 / Median = 5 / Mode = 5

Comments 1-7:

1. The difference between measures of central tendencies can only really be understood within the context of real life application.

2. Data analysis needs to be real world applications or it is meaningless and not worthwhile to students.

3. Real world is all over this problem! I like that students would be sent out to gather the data then report back.

4. Helpful for buy in but not helpful in solving the problem.

5. This problem is real life so need to explain as such.

6. Essential for adult application.

7. As always, the real examples are the best.

	1	2	3	4	5
DEMONSTRATE REAL WORLD APPLICATION	○	○	○	○	○

*

STRATEGY: USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES

Round 2 Ratings: 5, 5, 4, 4, 4, 4, 3
Round 2 Results: Mean = 4.14 / Median = 4 / Mode = 4

Comments 1-7:

1. Graphs and charts are a great way to visualize this concept.

2. Tables for organizing data is very helpful but will not be all the students need to interpret the data.

3. I would want to see students using charts, but I would not want to provide any for them. They should figure out what works best for this problem.

4. This would allow students to organize the information and extrapolate a formula or pattern.

5. Table would be extremely helpful for organizing the data and more clear understanding of what the data means.

6. Important for creating understanding and knowledge.

7. This a great way to get and organize the information you will receive.

	1	2	3	4	5
USE GRAPHIC ORGANIZERS, CHARTS, AND TABLES	○	○	○	○	○

*

STRATEGY: EXPLORE THE VOCABULARY

Round 2 Ratings: 5, 5, 4, 4, 4, 4, 2
Round 2 Results: Mean = 4.00 / Median = 4 / Mode = 4

Comments 1-7:

1. Identifying the three types of central measurements is a vital part of understanding this concept.

2. Understanding the vocabulary is key to knowing how to analyze the data.

3. Yes! This is a great problem for vocabulary. Lots of nice words to chat about.

4. The vocabulary was not that challenging.

5. Students need to understand the measures and what they mean or they cannot do this problem at all.

6. Important but not essential for mastering the concepts and skills.

7. This problem is very dependent on understanding what this question is asking. Exploring the vocabulary is essential to finding the correct answer here.

	1	2	3	4	5
EXPLORE THE VOCABULARY	○	○	○	○	○

STRATEGY: SOLVE/DEMONSTRATE USING TECHNOLOGY

Round 2 Ratings: 5, 4, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 4

Comments 1-7:

1. Technology will be needed to gather the information for this type of problem, but does not provide an opportunity to demonstrate the concept directly.

2. The technology can help do the number crunching and the students can still interpret the data.

3. Yes! Let students choose all sources for gathering data: newspapers, accuweather, weather channel, etc.

4. Allows for real world problem solving. Connects technology to math.

5. Can be used for calculating the various central measures so that more of the time can be spent understanding what they mean.

6. Important but not essential in demonstrating understanding.

7. A calculator won't solve this for you. Neither will google. You need to know what you are doing in order to solve this one.

	1	2	3	4	5
SOLVE/DEMONSTRATE USING TECHNOLOGY	○	○	○	○	○

*

STRATEGY: CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)

Round 2 Ratings: 4, 4, 4, 4, 4, 3, 3
Round 2 Results: Mean = 3.71 / Median = 4 / Mode = 4

Comments 1-7:

1. Scaffolding is always recommended!

2. Any time something can be connected to previous learning it makes it more real.

3. I would not scaffold, I would let them explore first them the next day I might tie back into previous lessons.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Relates to real life, you can build on concepts and problems they have done before to expand their knowledge.

6. Important but not essential for building knowledge.

7. Since you are comparing many cities, it would be easy to scaffold learning across them all.

	1	2	3	4	5
CONNECT LEARNING TO SIMILAR CONCEPTS (Scaffolding)	○	○	○	○	○

*

STRATEGY: PROVIDE EXAMPLES (Use different numbers to solve similar problems)

Round 2 Ratings: 5, 5, 4, 4, 4, 3, 2
Round 2 Results: Mean = 3.86 / Median = 4 / Mode = 4

Comments 1-7:

1. Examples are good, but the concept of a "rate" should not be reduced to plugging in numbers if possible.

2. Shows students what to do but not why necessarily.

3. YES! I love this and I do this daily. I try to practice at least 1-2 examples of each kind of problem they will encounter.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Can be used as simple problems to start - let's calculate the mean of these 6 numbers - to make sure they get the concept of mean.

6. Important for transferability of skills to similar problems.

7. This helps solidify learning, however, not a stand alone strategy.

	1	2	3	4	5
PROVIDE EXAMPLES (Use different numbers to solve similar problems)	○	○	○	○	○

STRATEGY: USE INQUIRY LEARNING (Student-led instruction)

Round 2 Ratings: 5, 5, 4, 3, 3, 3, 2
Round 2 Results: Mean = 3.57 / Median = 3 / Mode = 3

Comments 1-7:

1. This concept can be taught effectively using student-led inquiry provided the activities and questions are carefully created to guide students effectively.

2. Not sure about this.

3. Yes! Once the small groups got their information gathered I would like to see each group present to class what they found, what they did and how they did it.

4. Works well if students have an understanding of how to approach the problem.

5. Not sure this is needed here.

6. Essential for creativity.

7. I'm not sure that I would start there for this problem. I guess you could, but I would want to make sure they fully understand the process for 1 city, Then let them work together to find other cities.

	1	2	3	4	5
USE INQUIRY LEARNING (Student-led instruction)					

*

STRATEGY: PROVIDE PICTURES AND VISUALS

Round 2 Ratings: 5, 4, 4, 3, 3, 3, 1
Round 2 Results: Mean = 3.29 / Median = 3 / Mode = 3

Comments 1-7:

1. This concept should be taught with a graph.

2. Pictures and visuals do not help with the wide variety of information collected and used in data analysis.

3. I would like to see the groups provide pictures, but i would not provide them myself. That would be afterwards and for future problems.

4. This allows students to visualize the problem and figure out steps to problem solving.

5. See more of the tables and charts used more so than pictures.

6. Important in explaining and showing what they know.

7. Depending on what format your data is in, you may have visuals and graphs for his problem.

	1	2	3	4	5
PROVIDE PICTURES AND VISUALS	◯	◯	◯	◯	◯

*

STRATEGY: PROVIDE A TEMPLATE/MODEL

Round 2 Ratings: 4, 4, 4, 3, 2, 1, 1
Round 2 Results: Mean = 2.71 / Median = 3 / Mode = 4

Comments 1-7:

1. There is not a model or template that allows students to understand the concept, just plug in numbers.

2. I do not think this would work because every situation the students will come across is different.

3. Yes, you could provide a model, but I'd rather see what the students came up with on their own. I might model afterwards.

4. This would allow students to either work backward to solve the problem or apply the model to solving the problem.

5. Could use a template when trying to set form for collecting data.

6. Important for scaffolding and building knowledge.

7. You can use a problem solving model for this one, but that is about it. Maybe not the most effective.

	1	2	3	4	5
PROVIDE A TEMPLATE/MODEL	◯	◯	◯	◯	◯

*

STRATEGY: WORK INDEPENDENTLY (Practice Alone)

Round 2 Ratings: 5, 3, 3, 3, 2, 2, 2
Round 2 Results: Mean = 2.86 / Median = 3 / Mode = 2, 3

Comments 1-7:

1. Although independent practice is important to ensure individual student achievement, the most effective instructional method for this concept is collaborative.

2. After another method of instruction/exploration, this is beneficial.

3. I would prefer small groups with this, but independently would be an option.

3. I would prefer small groups with this, but independently would be an option.

4. Only if I wanted to see who knew this and who did not. Then I would provide extra support to those who needed it.

5. This would not be as effective as other methods with this type of "project" more than problem.

6. Essential to demonstrate mastery.

7. If you can't do one on your own, having a worksheet with 20 more isn't going to help.

	1	2	3	4	5
WORK INDEPENDENTLY (Practice Alone)	○	○	○	○	○

Remember to click on the "Submit" button below to properly submit your survey.

Prev Submit