

Mathematical Teaching Practices on Elementary Students' Mathematical Comprehension:

A Literature Review

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TEDUC 599: Culminating Project

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May 31st, 2024

Abstract

This research investigates mathematical teaching practices on elementary students' mathematical comprehension. Three themes were identified in the literature: the use of mathematical manipulatives, teacher instructional practices, and embedded language support. Research demonstrates that implementing specific mathematical teaching practices may support elementary students' mathematical comprehension. After the literature review section is an action plan with recommendations based on the literature for implementation of mathematical teaching practices in current elementary schools. In the discussion section, the challenges of implementation of mathematical teaching practices will be discussed with future research and suggestions for educators based on the research found.

Keywords: mathematical teaching practices, mathematical comprehension, mathematical manipulatives, teacher support moves, embedded language support

The Impact of Mathematical Teaching Practices on Elementary Students' Mathematical Comprehension

For many students, mathematics can be a difficult subject to master and comprehend. It is important that students are comprehending mathematics because it is present in their everyday life, not just in the classroom. There are many factors that can contribute and impact students' mathematical comprehension. This paper focuses on the research on mathematical teaching practices in elementary school that impact students' mathematical comprehension.

Context

Mathematics teaching practices impact and are connected to the local, regional, and national level. Locally and nationally, the pandemic has affected students' mathematical comprehension and put students' grade levels behind. According to OSPI (2024) only 27.9% of students in the Puget Sound area met math standards in spring 2023. In addition, locally, the Puget Sound area is very diverse and consists of students with diverse learning needs and funds of knowledge. Implementing a variety of different mathematical teaching practices might impact student's diverse needs.

In addition, math teaching practices connect to the regional level because Washington State has not met pre-pandemic levels in math. Mathematical teaching practices that support students' math comprehension have the opportunity to improve the proficiency rate. In 2019, the proficiency rate was at 50.3% and in 2023 it decreased to 40.8% (*19 School Data Hub. COVID, 2023*).

Lastly, mathematics is interconnected with the world at a national level and no matter what country you are in, mathematical language is the same. Math helps students make sense of the world and it helps them solve real life problems. Mathematics is a commonality between

countries and provides a way to communicate to each other. According to the OECD (2023) the United States math scores hit an all-time low on the international PISA exam when they scored a 465 out of 1000 in 2022 and was ranked 26th in math out of 81 countries. COVID-19 had a influence on the PISA scores, however, the United States education system needs support on providing their students with engaging mathematical content to improve future national scores.

Importance

Mathematical teaching practices are important to students because all students have different needs and ways of learning and comprehending information. It is essential that students understand that there are multiple ways to demonstrate their thinking and comprehension. Students bring different backgrounds to the classroom that could potentially impact how they learn math. Mathematical practices are also important to the community. The community and future generations are asked to work with mathematical terms every day, not just in the classroom. Students will need to be able to use their mathematical knowledge and apply it to their careers, grocery shopping, budgeting, etc.

In addition, mathematical teaching practices are important to me because as a lower elementary school teacher, it is important that I am meeting the needs of all my students. Mathematics is present in every aspect of students' lives, not just in the classroom. Presenting information and material in a range of ways demonstrates to students that there is not one way to solve a problem. In addition, it is important that a teacher presents information in different ways to meet all their students' learning styles. Lower elementary students learn basic foundation mathematics and as students get older math gets more complex and they begin to build on that foundation. It is important that the foundation is strong, and they are able to retain information, so they have the ability to build on their prior knowledge. I loved learning mathematics during

my elementary education and I would like to pass down my passion for the subject to my students.

Purpose

The purpose of this project is to implement effective mathematical teaching strategies into my own classroom to support elementary students' mathematical comprehension and learning. I hope to gather information that will inform teachers of what strategies and techniques work best to support the diverse range of students in the classroom.

Focal Questions

Three focus questions guided this project:

- According to the research, what mathematical teaching practices are most impactful on mathematical comprehension?
- According to the research, how does classroom climate impact students' mathematical learning and comprehension?
- According to the research, what challenges do teachers have in current schools for implementing effective mathematical practices?

Literature Review

This paper explores the research on mathematical teaching practices in elementary education classrooms and the impact the practices have on students' comprehension. Comprehension refers to students understanding the meaning of what is being presented to them and then applying their previous knowledge and general knowledge to solve the problem at hand (Hadianto et al., 2021). With the diverse range of students' learning needs, research provides educators different strategies and practices that can be implemented in the classroom to meet their students' needs. Mathematical teaching practices have been

demonstrated in research to be critical in supporting and developing students' mathematical knowledge and learning. These research practices give teachers strategies and techniques to implement into their classroom to help students reach learning goals and their learning needs.

The purpose of this project is to review the literature on mathematical teaching practices that accommodate the diverse learning needs of elementary students. Mathematics can be challenging for students, so my hope is to provide meaningful mathematical learning experiences for students and apply these practices to my own classroom. This literature review will explore three themes: the use of mathematical manipulatives, teacher instructional practices, and academic language support. Mathematical manipulatives allow students to learn concepts through a hands-on approach. Teaching instructional practices are practices that help students reach and achieve their mathematical goals. In addition, language can be a barrier for students in understanding mathematical concepts, so research suggests implementation of embedded language supports.

The Use of Mathematical Manipulatives

This section explores the research on the use of mathematical manipulatives. Mathematical manipulatives are objects, charts, and activities that engage learners while helping them develop their mathematical skills. Some examples of math manipulatives are pattern blocks, dominoes, online math games, two color counters, base-ten blocks, and geoboards (Crowe, 2022).

Virtual Mathematical Manipulatives

According to multiple studies, virtual math manipulatives have shown to increase students' understanding and comprehension of mathematical concepts. Research has demonstrated that implementation of these manipulatives has led to increased test scores.

Virtual manipulatives implementation in small group settings encouraged students' mathematical comprehension and communication. Silva, Martins, Costa, Cravino, and Lopes (2021) explored mixed method research about virtual manipulatives impacting subtraction comprehension in lower elementary and students' test scores. A kindergarten class of 29 students were placed into 13 pairs and each pair had one computer to share. The experiment consisted of an individual written pretest, intervention stage, and individual written posttest. The intervention stage consisted of six sessions that followed the Zone of Proximal Development which students were asked to solve a set of word problems that involved addition and subtraction using virtual manipulatives. Students were asked to write an explanation of the problems and the problems were analyzed according to the task analysis criteria created by the research team which consisted of three levels. Data was collected using students' written productions, participant observation, field notes, audio, and screen recordings. The researchers found that the evidence of students' mathematical communication and subtraction comprehension improved when implementing technology and virtual manipulatives. The use of virtual manipulatives allows for visualization and reduce confusion which made mathematical concepts more understandable. However, the selection of manipulatives should align to the learning objective so that the implementation can help with comprehension.

Virtual mathematical manipulatives implemented with technology-based games encourages students' engagement and comprehension. Shin, Sutherland, Norris, and

Soloway (2012), professors and research scientists in the School of Education at the University of Michigan and University of North Texas, conducted a quantitative method research study on the effects of mathematical technology games in elementary school on students test scores. For the first five weeks, forty-one second graders from two classes used either technology-based games or paper-based games. The paper-based game used was flash fact cards and the technology-based game used was Skills Arena. The next 13 weeks of the experiment, both classes used technology-based games for 15 minutes. The class that started with technology-based games used it twice a week and the class that switched to technology-based games used them three or more times a week. Both groups were given an arithmetic test at the start of the experiment, the same arithmetic test at the five-week mark, and a post arithmetic test at the end of the 13 weeks. The data was analyzed by comparing the pre and posttest. The researchers found that at the five weeks mark the technology-based game class gained 11% and the paper-based class only gained 4%. At the end of the experiment, the paper-based game class that switched to technology-based games increased 11% and the other class only gained 1%. The study demonstrates that technology positively impacts elementary students' learning of arithmetic regardless of ability level.

According to Lister et al. (2019), the implementation of virtual manipulatives has increased students' engagement and mathematical comprehension. Preschoolers, kindergarteners, and second graders participated in a study that investigated student engagement with virtual base-10 blocks and their mathematical comprehension (Litster, Moyer-Packenham, and Reeder, 2019). Students were instructed to use a base-ten app on an iPad. The data was collected using a GoPro that captured video recording of children's interactions with the base-10 blocks app on the iPad. In addition, students were interviewed,

and wall cameras captured the interviews. The results identified three themes with the use of virtual base-10 blocks: verification, self-correction, and making connections. Students who engaged with the virtual base-10 blocks showed more opportunity to self-correct errors, make connections to visual features, and were given feedback right away using the app. The data collected demonstrated that using virtual manipulatives allowed students to make connections and deepen their mathematical thinking. Preschool demonstrated 105 total frequencies of engagements, kindergarten demonstrated 60 total frequencies of engagements, and second graders demonstrated 44 total frequencies of engagements.

Virtual manipulatives have shown to impact students' mathematical comprehension. However, the following study wanted to compare the use of physical manipulatives to virtual manipulatives. Chang, Yuan, Lee, Chen, and Huang (2013) conducted a study on third grade students' math comprehension when using virtual mathematical manipulatives compared to physical manipulatives when learning area. The participants included two third-grade classes which one was the control group and the other the experimental group. The experimental group was given virtual manipulatives called Magic Board and the control group used physical manipulatives. Magic Board is an online platform that provides students with virtual manipulatives. This study used pre and posttest scores to collect data. The researchers concluded that the Magic Board virtual manipulatives positively impacted students' mathematical comprehension. The experimental group outperformed the control group in the three concepts of area: preserving area (9.2%), comparison of area using a nonstandard unit (10.1%) and measuring area using multiplication (11.1%). However, the use of virtual and physical manipulatives results was not significantly different. Virtual manipulatives might be better when students are asked to work with 3D shapes and areas.

The use of manipulatives depends on the mathematical concept and strategies that are being used by students.

Physical Mathematical Manipulatives

Physical manipulatives have shown similar results to virtual manipulatives when implemented and used correctly. Liggett (2017) researched the impact of math manipulative usage on second graders test scores. The participants consisted of 43 second graders that were randomly assigned to a control group and treatment group, and both given the same pre and posttest. The treatment group was the only group to use manipulatives which were plastic unifix cubes. This study took place over a period of two weeks. The first week consisted of giving the control and treatment group the pretest without manipulatives. The following week consisted of giving the posttest, however only the treatment group were given the plastic unifix cubes during the posttest. The data demonstrated that the use of manipulatives increased student posttest scores. For instance, the data showed that the control group went from 77% to 79% and the treatment group went from 87% to 97%. However, the authors discussed that if manipulatives are used inappropriately, it may cause frustration or confusion, and ultimately disrupt student motivation and overall learning opportunity. With implementation of virtual or physical manipulatives into the classroom, teachers need to do what is best for their students' learning and consider what manipulatives their students can use.

The study above demonstrates whole class implementation of physical manipulatives. Similarly, small group interventions that implemented mathematical manipulatives positively impacts students' mathematical comprehension and test scores. Mononen and Aunio (2016) conducted a research study on first grade mathematical small

groups which consisted of practicing verbal and object counting skills and the intervention included explicit teaching and use of manipulatives. The intervention was provided in small groups twelve times during eight weeks. The data was collected during three assessment sessions which were in September, December, and March. The counting skills intervention focused on practicing number range one to twenty in small groups of students. In addition, it included explicit teaching and followed a detailed activities and procedures. Students were able to use mathematical manipulatives which included structured dot cards, ten frames, and games. Students in the intervention group demonstrated greater comprehension of subtraction and addition than the control groups. The intervention group made a mean gain of 14.45 from the first assessment session to the second assessment session. In comparison, the control group made a mean gain of 12.65 from the first assessment session to the second assessment session. Manipulatives allow students to represent their thinking and the math problem involving little risk.

Using drawings to develop students mathematical word problem skills may not have a significant impact on students' mathematical comprehension. University of Szeged's researchers, Csikos et al. (2012), addressed the impact of mathematical visual representations and drawings on the development of third-grade students' knowledge about word problem-solving. The experiment involved five experimental and six control classes of third-grade students. The experiment consisted of 73 basic word problems and 20 lessons. Teachers in the experimental group were given visual representations that went with the lesson plans. Students in the experimental group were asked to use visual representations and teachers also demonstrated visuals. Both the control and experimental group were given a pencil and paper pretest and posttest which consisted of two tests,

arithmetic skill, and word problem test, to calculate the results. The data was analyzed by comparing the scores of the pre and posttest which both groups outperformed their pretest in arithmetic and word problems. The authors' results showed that after the six-week intervention period, there were no significant differences in the pre and post-test between the control and experimental groups. However, there was a significant change in the experimental group students' beliefs about mathematics and their math identities. The experimental group scored a mean of 25.31 (arithmetic skill test) and 2.57 (word problem test) on the pretest, and 27.00 (arithmetic skill test) and 4.12 (word problem test) on the posttest. In comparison, the control group scored a mean of 26.74 (arithmetic skill test) and 3.51 (word problem test) on the pretest, and 27.56 (arithmetic skill test) and 4.06 (word problem test) on the posttest.

These research examples demonstrate that mathematical manipulatives can come in a variety of different forms: physical or virtual. In addition, the studies have demonstrated that when implemented and used properly, manipulatives can have a great impact on students' comprehension and understanding of mathematical concepts and material. However, manipulatives can also have a negative effect on students and result in confusion and frustration. To further investigate mathematical teaching practices on elementary students' comprehension, the next section will look at the use of teacher instructional practices in the classroom.

Teacher Instructional Practices

This section explores the research on teacher instructional practices used in the mathematics classroom. Teacher instruction practices are the techniques used to help students achieve learning outcomes and master the math concepts and materials. An

instructional practice includes teacher moves which helps students to think deeper about the material and why they are taking the steps they are taking to solve the problem (*Teaching methods*, 2024).

Visual to Spoken Word Connections

Studies have shown that the use of teacher's visual to spoken word connections has increased students' mathematical comprehension and understanding of material. Visuals include hand gestures, written word, pictures, and diagrams.

Simultaneous gesture and spoken word support students' comprehension rather than just spoken word. Congdon, Novack, Brooks, Hemani-Lopez, O'Keefe, and Goldin-Meadow (2017) studied how incorporating gestures into math instruction improves learning and students' ability to generalize and understand information. Seventy-two third graders were chosen based on their pretest scores of incorrectly answering six questions and were randomly assigned to one of the three conditions: speech then speech, speech then gesture, and speech with gesture. In all conditions, the experimenter and child solved four new basic problems on the dry-erase board. In the gesture and speech intervention, the experimenter explained if the answers were correct or incorrect using gesture and speech together. The other two intervention groups did not gesture while explaining answers. Retention was measured with follow-up visits the following day and four weeks after the initial testing day which consisted of basic and generalized assessments. Children were given four basic problems and five generalized problems that were identical to the pretest for both posttests. Each child's response to each problem on the pre and posttests were categorized as incorrect or correct. Congdon et al. concluded that children who received simultaneous speech and gesture instruction were better able to retain and generalize a mathematics lesson than

children who received the same speech and gesture presented sequentially. Gesture is not enough to facilitate deep learning, generalization, and retention, it must be presented simultaneously with speech.

Gesture and spoken word connection can also be implemented during word problem intervention to support students' mathematical understanding. Swanson et al. (2015), researchers from University of California, investigated the role of word problem strategies in second and third grade classrooms. The study consisted of four groups: verbal-only strategies, verbal and visual strategies, visual-only strategies, or untreated control groups. World problems are an important part of mathematics. Students are asked to use their funds of knowledge and mathematical skills and apply it to a real-life situation. Verbal-only strategies consisted of underlining the question, circling important words and numbers. Visual-only strategies consisted of correctly placing numbers into diagrams. Swanson et al. concluded that children with math difficulties performed better using visual-only strategies and children without math difficulties performed better using verbal and visual strategies. This study demonstrated how each student has their own learning needs and it is important that teachers use a variety of different strategies in the classroom to address those needs. Not every student learns and comprehends material the same.

Teachers correctly using gestures during mathematical lessons can support students and reduce mathematical confusion. Henderson Pinter et al. (2018) investigated teachers' instructional moves and how they may affect the potential understanding of mathematical concepts for students. The data was collected by using observations and observers tracked teachers' misconceptions during the lesson. Henderson Pinter et al. focused on misconceptions regarding representations and language use. The results indicated that the

misconceptions were conveyed through a lack of clarity or overgeneralization. The teachers who showed misconceptions during their lesson followed the curriculum material very closely, had students work individually not in partners or small groups, and did not connect manipulatives with language. For instance, a teacher when working with measurement used a scale to measure solids without making an explicit connection to the weight of the solid object. However, the teachers who demonstrated not misconceptions had a very structured lesson, clear learning goal, and used manipulatives with connection to language. For example, the teacher provided visuals and stated the question on the board where students can reference the problem. This study demonstrates the important of explicit teaching and making connections between representatives and language.

Teacher Support Moves and Mathematical Discourse

Multiple studies have examined the relationship of mathematical discourse in the classrooms and the impact it has on developing students' mathematical learning and comprehension. Discourse in the classroom can lead to students to think deeply about mathematical concepts and ideas, expand their understanding, and build confidence in their mathematical identity.

Teachers explicitly modeling academic discourse shows to support students' ability to use academic vocabulary and engage with their peers' work. Researchers from University of Connecticut and Saint Joseph's University conducted a study investigating the relationship between teacher's implementation of two specific discourse-related instructional practices on students' mathematical achievement (Firmender et al, 2014). The instruction practices included engaging students in verbal communication in math and encouraging the use of appropriate math vocabulary by implementing think time,

agree/disagree and why, partner talk, repeat and check, and add on. The data was collected using a pre and posttest of the Open-Response Assessment. Firmender et al. concluded that the higher the teacher's mean implementation score for the instructional practices of verbal communication and mathematical language, the higher the student's percentage gain scores on Open-Response Assessment would be for that teacher's student. The average change in the students' score on the Open-Response Assessment was 43%. Students engaging with mathematical vocabulary allows them to create connections and use those vocabulary words when addressing their peers and explaining their work. Teachers demonstrating and modeling the academic vocabulary and mathematical discourse in the classrooms provides students with examples and ideas on how to engage with the material that is being taught.

To support academic discussion, students' ability to listen to their classmates has shown to be important and impact their mathematical comprehension. Hintz and Tyson (2015) investigated what teacher support moves can improve student listening and mathematical comprehension. The research included a fourth-grade classroom. During the lesson, students and the teacher listened to each other evaluatively, interpretively, and hermeneutically. They listened to determine if the ideas being presented were alike or different from their own ideas, they built on each other's ideas, and also revised each other's thinking. The teacher used support moves of allowing the students to share their work, asking students to explain each other's thinking, and revoicing the strategies. In addition, the teacher facilitated the discourse by directing interactions, directing the focus, and asking genuine questions. For instance, nine percent of the turns were identified as the teacher asking a genuine question and four percent were the students. Genuine questions supported teacher and student understanding of another's thinking and ideas. These types of

questions support students to do complex listening to understand and comprehend mathematics as well as their peer's work. The results demonstrated that teachers supporting complex listening supports students' mathematical comprehension and it vital to make sense of mathematics.

The implementation of academic discussion and teacher support moves on students' mathematical comprehension was analyzed over the course of two weeks. University of California's researchers, Franke, Turrou, Webb, Ing, Wong, Shin, and Fernandez (2015), researched how teachers can foster students' engagement and productive struggle using teacher support moves to create deeper discussions and comprehension. The participants consisted of 12 classrooms across pre-k to sixth grade. The formal data collection consisted of multiple days of observations which were two to three observations an hour each over the course of 2 weeks. Video and audio setup was used to capture whole-class conversation and small group conversation. Teacher talk moves included teachers asking students to explain someone else's solution, discuss differences between solutions, and making suggestions to other students about their data. The results for the video and audio observations indicated that teacher talk moves promote higher-level student math engagement with each other's ideas. 62% of teacher moves led to students engaging with each other in some mathematical ways. 41% of teacher moves led to students engaging with another's idea at a medium level and high level. Each type of teacher move led to a range of engagement levels. The data has shown that teachers facilitating a positive learning environment where students are asked to engage in other students' work and ideas contributes to positively impacting comprehension.

Similar to the study above, Webb et al. (2014) study analyzed students' academic discussion and recorded engagements to determine effectiveness of academic discourse on students' comprehension. Webb et al. (2014) research on teacher moves that support student participation took place in a United States elementary school and the participants ranged from eight years old to ten years old. The teachers in the study used teacher support moves such as asking questions that have the students add details to another student's idea, referencing another student's ideas, partner work to co-construct solutions, and proposing correct information in response to incorrect information. Students and teachers were videotaped as they discussed how to solve mathematical problems during whole group and small group discussions. The results indicated that teacher support moves and promoting questions impacted students' comprehension positively because students were thinking deeply about their peers' ideas and strategies. Adding detail to another student's idea and partner work to co-construct solutions showed the highest level of engagement. Referencing another student's work without using detail showed the lowest level of engagement. Students who demonstrate a high level of mathematical engagement showed a high level of achievement on the posttest assignment. In order to facilitate a high level of engagement and thinking, students need to be interacting with other students' ideas and thinking. Teacher support moves help create this kind of mathematical discourse community.

Teacher support moves used effectively can impacts students' mathematics, however when used ineffectively it can negatively impact learning. Murata, Siker, Kang, Baldinger, Kim, Scott, and Lanouette (2017) examined the impact teacher talk moves have on student learning in two first grade classrooms. The study consisted of two first grade classrooms located in a low-income, urban community in the United States. From

November through February, the teachers taught short math-talk lessons, The lessons were videotaped once a month and teaching material and student work was collected after lessons. The data was collected using student interviews and observations. Both first grade classrooms in the research used talk moves to facilitate discussion in the classroom. However, the second classroom incorporated a wider variety of ideas and demonstrated more of a student and teacher lead approach and showed more growth in mathematical comprehension. For instance, the second classroom allowed students to discuss their own ideas, the teacher asked questions to help extend students' ideas and discussion, representations to illustrate student explanations using a variety of different strategies The first classroom, math talk was structured more tightly, students closely followed the teachers talk moves prompts, and student choice of strategies were narrowed. The results from Muarata et al. suggested that in order for teaching talk moves to be used effectively, teachers need to break down, represent, and discuss student strategies while connecting it with other strategies.

Mathematical teacher support moves that encourage responsive teaching improved students' mathematical comprehension. Two researchers, Jacob and Empson (2015), explored responsive teaching which is a "type of teaching in which teacher's instructional decisions about what to pursue and how to pursue it are continually adjusted during instruction" (p. 185). The study investigated teacher support moved to enhance students' mathematical comprehension and understanding. For example, posing general starter questions to students, facilitating students' explanations, encouraging students to use other strategies, and connecting student's' thinking to symbolic notation. The participants consisted of 25 fourth and fifth graders. The data was collected by classroom observations

and student interviews where the teacher learned about their thinking. The research demonstrates that there is not one teacher support move that is effective in every situation. Teacher support moves provide students to engage deeper with their mathematical thinking and make connections with their classmates work and ideas.

Research has shown that teacher professional development has positively impacted students' mathematical comprehension. Drew Polly (2015), a researcher from the University of North Carolina, conducted a study that explored the impact a year-long math professional development had on students' mathematical understanding. The participants included two elementary teachers who participated in the professional development and two elementary teachers who did not. During the professional development, teachers were taught support moves and strategies to support students in their mathematical understanding. The results demonstrated that teachers who participated in the professional development provided more opportunity for students to generate multiple representations, students using correct resources, and students' ability to communicate their mathematical thinking with their classmates. For instance, the participants in the beginning of the school year showed zero tasks that were student directed. By the end of the year, the participants in the development showed three to six tasks that were student-directed compared to the comparison teachers that still showed zero student-directed tasks. Professional development provides teachers with strategies and examples of support moves that can be used in the classroom to impact students' mathematical comprehension such as use of manipulatives and facilitating the communication of mathematical ideas.

Student Centered Learning

Multiple studies have shown that student-centered learning can improve students' mathematical comprehension. Student-centered learning allows for students to have more of a role in their learning and the classroom.

Newer studies have explored the impact student-centered learning has on students rather than a teacher-centered classroom. University of Eastern Finland's researchers, Lerkkanen et al. (2016), examine child-centered versus teacher-centered teaching practices in first grade Finland classrooms. The participants included 93 first grade classrooms that were assessed on their math and reading skills at the beginning and end of first grade. Teaching support practices were observed in 29 classrooms. The data was collected by classroom observations which included two visits to each classroom, conducted on two different days by one pair of observers. The observations lasted for over three hours and included both math and reading lessons. The results showed that child-centered teaching practices were positively associated with math skills and teacher-directed teaching practices were negatively associated with math skills in a typical first grade classroom in the spring. The more child-centered practices that the teacher facilitated and incorporated into the classroom, the more the child's mathematical comprehension increased.

Similar to the research above, one example of student-centered learning is incorporating a project-based learning activity. Lazic et al. (2021) investigated the effects of project-based learning on student achievement in lower elementary mathematics education and whether the project-based model was equally acceptable to students at different comprehension levels. One hundred and forty-seven third graders from two different elementary schools were placed into either the project-based experimental group or the control group based on student achievement and pretest scores. Over the course of two

weeks, students in the project-based learning had the opportunity to solve problems that connected to their daily lives such as using money to buy or sell cookies and measuring the volume and mass while baking the cookies. Then both groups were given a mathematics posttest after the implementation of the experimental program. The data was analyzed by using the difference in the pre and posttest scores. In addition, the researchers observed students' behavior, motivation, and problem-solving skills during the lesson. The results show that students in the project-based teaching experimental group outperformed students in the control group. On the pretest, the experimental group scored a mean of 63.01 and the control group scored a mean of 62.84. On the posttest, the experimental group scored a mean of 69.34 and the control group scored a mean of 63.14. Project-based learning shows greater motivation and autonomy for learning and is more self-sufficient.

Implementing Other Strategies

In addition, a study has found that implementing reading strategies are not always effective in impacts students' mathematical comprehension. Fourth graders from Turkey were asked to participate in a study on how using a KWL chart might impact students' mathematical comprehension and understanding (Usta and Yilmaz, 2020). The study consisted of a control group that continued the current instructional program, and the experimental group used the KWL reading strategy. The data was collected used pre and posttest scores. After conducting the study, Usta and Yilmaz concluded that there was no significant difference in pre and posttest scores for the experimental and control group. The experimental group scored a mean of 16.67 and the control group scored a mean of 16.35. However, the KWL chart was effective in helping the experimental group understand the problem but did not help them find strategies and solve the problem correctly. This study

demonstrates a teacher support strategy that does not positively impact students' mathematical comprehension and ability to solve problems.

The implementation of physical activity does not always enhance and support students' mathematical understanding and comprehension. Mullender-Wijnsma et al. (2016) investigated the use of physical activity in teaching mathematical lessons has on students' academic achievement and comprehension. The study took place for two whole academic years and consisted of a control and experimental group. Mullender-Wijnsma et al. concluded that there was no significant difference in the control and experimental groups reading, spelling, math speed, and math test results. For example, in the beginning of the study the control group scored a mean of 42.05 (math speed) and 53.94 (math). In comparison, the experimental group scored a 38.82 (math speed) and 48.03 (math). At the end of the study, the control group scored a mean of 78.35 (math speed) and 82.83 (math), and the experimental group scored a mean of 83.81 (math speed) and 82.36 (math). As you can see from the data, teachers incorporating physical activity into mathematical lessons did not show much growth in mathematical comprehension.

These research examples demonstrate that teacher instructional practices can positively impact student comprehension by facilitating productive mathematical discourse in the classroom. In addition, the studies have demonstrated that teacher support practices can look different in classrooms but when used correctly to foster a child-centered approach, it allows students to think deeply about their own and classmates' ideas and thinking. However, when teacher support moves are restricted such as the strategies that students use and how students process the information, it does not create as much growth in students' comprehension. To further investigate mathematical teaching practices on

elementary students' comprehension, the next section will look at the use of embedded language support.

Embedded Language Support

In this section, I will be looking at the research around supporting language development in the mathematics classroom, also known as embedded language support. Mathematics has a large amount of academic language and vocabulary words which young students only see and hear during their math lesson.

Mathematical and Reading Skills

Multiple studies examined the relationship between reading skills and mathematics skills. Research has demonstrated that students' reading skills greatly affect their mathematical skills.

Reading skills and mathematical skills tend to correlate. Hadianto et al. (2021), researchers from Indonesia, conduct a study on the correlation of reading comprehension and mathematical comprehension. The participants were from three schools with different accreditation levels that were given two tests: a word problem test and a numeracy test. Both tests were given verbally to students. The results demonstrated that students with high reading comprehension outperformed students with lower reading comprehension. For instance, students in group A had a mean reading competency of 54.5 and a mean counting competency of 55.3. In comparison, students in group C had a mean reading competency of 38.5 and a mean math competency of 41. Reading and mathematical comprehension are correlated and reading competency impacts mathematical comprehension.

There are different factors that can contribute and impact students' reading skills. For instance, Fuchs et al. (2018) researched text comprehension and oral language as

predictors of word-problem solving. The data concluded that start of the year text comprehension and language were a strong indicator of word-problem solving. Students with higher reading levels and comprehension demonstrated higher word-problem outcomes. In 2021, Fuchs and other researchers from Vanderbilt University, University of Missouri, and Florida State University addressed the effects of word-problem intervention with versus without embedded language comprehension instruction on at-risk first graders' word-problem performance. The participants consisted of at-risk first graders from twenty-one schools which were randomly assigned to four conditions: word-problem intervention with embedded language comprehension, the same word-problem intervention without language comprehension, structured number knowledge, and a control group. The data was collected using a pre and posttest. Fuchs et al. (2021) concluded that students in the word-problem with embedded language comprehension outperformed the other students based on the test scores.

Not all reading strategies can make a large impact on students' mathematical comprehension. Hamidi et al. (2024) researched the effectiveness of integrating reading strategies and working memory on basic math and problem-solving skills. The study included a control and experiential group of fifty second graders. The experimental group consisted of 20 intervention lessons that taught reading strategies to improve math comprehension. The control group did not receive any intervention and the data was determined using a pre and posttest. Some examples of the reading strategies implemented were illustrating the problem and using a diagram to organize information. The results showed that the experimental group outperformed the control group but not by a significant difference. Teaching reading strategies such as organization of thoughts and use of context

clues results in students better comprehending story problems. Hamidi et al. concluded that not a drastic amount of growth was observed between the two groups, however, more growth was seen within the experimental group when explicitly teaching reading strategies.

Mathematical Story Books

Researchers have examined the impact mathematical story books have in the classroom. Research has demonstrated the use of storybooks in mathematical classrooms have shown to impact students' mathematical comprehension and academic vocabulary understanding. University of Delaware's researchers, Hassinger-Das et al. (2015), investigated quantitative method research on examining whether a storybook reading intervention targeting mathematics vocabulary and associated number concepts would increase lower elementary students' vocabulary knowledge and number competencies. The authors address how providing help with number concepts in a language-rich context improves learning outcomes for students with demonstrated low number knowledge. The researchers found that the mathematics vocabulary intervention groups outperformed the other groups on measures of mathematical vocabulary, both in terms of vocabulary words that were part of the intervention and ones that were not. Picture books have shown to be a great resource to engage students in academic vocabulary. Students are participating in discourse and using academic language in discussions. Mathematical picture books demonstrated to students that mathematical language is not only used in the classroom, but in their everyday life outside the classroom.

In comparison, implementation of mathematical storybooks in elementary classrooms have had inconsistent results. Casey, Erkut, Ceder, and Young (2008), conducted a study of the use of storytelling to improve students' mathematical

comprehension like Hassinger-Das et al. (2015) but received different results. The study consisted of kindergarten students who were placed in the control group or experimental group. The experimental group were given a picture book about geometry skills and vocabulary. Data was collected using pre and posttest scores. After the intervention, the data demonstrated that the use of storytelling did not show significant growth in student's mathematical comprehension and use of vocabulary. For instance, the control group had higher pretest scores than the experimental group: boys had a mean of 8.25 and girls had a mean of 8.34. In comparison, the experimental group's girls had a mean of 6.42 and boys had a mean of 7.23. The posttest scores of the experimental group were 10.98 (girls) and 10.69 (boys) and control group was 10.54 (girls) and 11.45 (boys). The girls in the experimental group outperformed the girls in the control group, however the boys in the experimental group did not outperform the boys in the control group. Storytelling and picture books of mathematical concepts and vocabulary does not demonstrate consistent impact on students' mathematical comprehension.

Academic Vocabulary and Discourse

Multiple studies investigated the impacts mathematical classrooms discussions explicit teaching has on students' mathematical comprehension and language. Research has shown that facilitating mathematical discourse in the classroom by partner sharing, whole class sharing, and explicitly using and teaching academic vocabulary have shown to positively impact students' mathematical language.

Explicitly teaching academic vocabulary with repetition can support students' mathematical learning. Moffett and Eaton (2019) explored mixed-method research of the Promoting Early Number Talk project on classroom mathematics talk. Five kindergarten

classrooms from different schools in Northern Ireland with about 30 students per class participated in the study. At the beginning of the study, teachers explored the PENT project and had the expectations explained to them about it. Teachers implemented ideas and activities of number talk over a six-month period into their classroom. For example, explicitly teaching academic math vocabulary and using math vocabulary in other areas than just math such as lining up in line order. During the six-months, teachers reflected in journals and identified two students and maintained their ongoing record of their progress in data. Midway through the study, teachers came back together to reflect on data and do another group interview which was audio-recorded. The data was collected by using an online questionnaire on the effectiveness of the project and group interviews which allowed for more in-depth exploration. The transcripts of all three interviews (at the outset, mid-point, and conclusion of the project) were read independently by the two researchers and thematic analysis used to identify key themes in the discussions. This involved color coding similar comments, themes, and sub-themes in each response. The researchers then met to compare initial findings and discovered a high degree of correlation in the themes and sub-themes identified. In addition, participating teachers collected their students' numerical data in mathematics. The results indicated that the PENT project had a positive impact on teacher professional development, teacher practice, and children's learning. The authors' findings are important because it demonstrates that explicitly teaching math academic vocabulary and with repetition impacts students use of the vocabulary words. This research study reveals that using mathematical vocabulary words outside of math lessons helps students grasp a deeper understanding of the words and provides examples of implementing them in their daily lives.

Cooperative learning is one way to encourage students use of academic vocabulary and support their learning. A study in Ireland investigated the impact cooperative learning as on elementary students' mathematical language development (Byrne and Prendeville, 2019). Many social constructivists suggest that social interaction is important for language development. The study consisted of a control group and an experimental group. The experimental group's lessons revolved around cooperative learning and the control group completed the tasks individually. Bryne and Prendeville concluded that cooperative learning improves the usage of mathematical language. For instance, in the post-intervention interview, students from the experimental group used more weight/mass specific language, increased their mathematical critical thinking language, and they employed a wider variety and quantity of mathematical language than the control group. Cooperative learning has demonstrated that it can be efficient in supporting students' mathematical language. Students are able to communicate with one another which leads to more exposure to academic language.

In addition, language can create a barrier for students when working with word problems. Researchers, Luevano and Collins (2020), studied the effectiveness of appropriate problem-solving instruction when incorporating video modeling and vocabulary instruction on students' mathematical comprehension and understanding. The participants included multilingual elementary students and the intervention consisted of culturally relevant information and the students' native language were explicitly incorporated into word problems and instruction. Luevano and Collins concluded that implementation of culturally relevant information and native language increase student participants' mathematical comprehension and word problem outcome. This practice can be applied to

all students not just multilingual students. Incorporating culturally relevant information allows students to use their funds of knowledge and connect their math thinking to their daily lives. This strategy has demonstrated that it can improve mathematical language acquisition and support students' understanding of the material.

These research examples demonstrate that embedded language comprehension and reading strategies can positively impact student comprehension by facilitating a deeper understanding of story problems and their everyday lives. In addition, the studies have demonstrated that embedded language comprehension and reading strategies can look different in every classroom and it may not work for every student. However, word problems require multiple steps thinking and when embedded language comprehension strategies are implemented into the classroom, students can identify key words, numbers, and details to help them determine the solution.

Conclusion

Thus far, I have explored the research on the use of mathematical manipulatives, teacher support moves and methods, and embedded language support. I have learned that there are many factors that contribute to impacting students' mathematical comprehension. From these three sections, we saw the impact mathematical manipulatives have on students' learning. Manipulatives provide a hands-on approach to learning which targets students' learning needs when used correctly (Mononen and Aunio, 2016). In addition, the research has shown the importance of teacher support moves and how to facilitate a rich mathematics discourse where everyone in the classroom is involved (Muarata et al., 2017). Lastly, the research has demonstrated how to integrate embedded language support in mathematics classrooms, such as picture books, explicitly teaching reading strategies and story problem

language, and using mathematical vocabulary outside of the classroom (Fuchs et al., 2021; Moffett and Eaton, 2019; Hassinger-Das et al., 2015). In the next section, I will look at the recommendations from this literature and apply it to my school site.

Action Plan

The purpose of this project is to explore the research on effective mathematical teaching strategies that impact elementary students' mathematical comprehension. This question was explored through the themes of the use of mathematical manipulatives, teacher instructional practices, and embedded language support.

In the practice section of the action plans below, I am referring specifically to an elementary school in the Puget Sound area where I student taught at during the 2022-2023 school year and was a long-term substitute for in the 2023-2024 school year. This elementary school is classified as title 1 and includes a diverse population of students. Over half of the students at this elementary school qualify for free or reduced lunch and minority enrollment is 72% of the student population. The action plans below will cover teacher mathematical engagement practices, embedded language support in mathematics, and the use of mathematical manipulatives. Some of the recommendations in my action plan are directed towards teachers, principals, and instructional coaches in the school while others are for the school district.

Teacher Mathematical Engagement Practices

The literature has identified a few specific teacher mathematical engagement strategies that positively support elementary students' mathematics. Teacher instruction practices refers to the techniques used to help students achieve learning outcomes and master the math concepts and materials. I pulled out two specific dimensions of strategies, manipulatives and language support, that will be handled separately. In the first action plan table below, I will discuss my

literature findings on the implementation of teacher engagement practices and the influence it has on students’ mathematical comprehension and understanding. In addition, I will address what practices my school is using with the implementation of teacher instruction practices and what I suggest based on the research.

Table 1

Teacher Instructional Practices Action Table

Research	Practice	Recommendation
<p>Studies have shown that the use of teacher’s instruction practices of connecting visuals to spoken word has increased students’ mathematical comprehension and understanding of material (Congdon et al., 2017; Swanson et al., 2015; Henderson Pinter et al., 2018)</p>	<p>Majority of the teachers at my school do implement this teaching practice by having visuals such as posters with written word for students. However, most teachers do not use hand gestures with spoken words regarding mathematical vocabulary and concepts.</p>	<p>I recommend that the district provide teachers with training regarding the importance of spoken word with visuals for students’ learning. In addition, instructional coaches should provide examples and ideas on how to implement hand gestures with spoken word to connect mathematical vocabulary with a visual and motion.</p>
<p>Teachers instructional practice of supporting and fostering students’ engagement and participation in mathematical discourse in the classroom has shown to positively impact students’ mathematical learning and comprehension (Firmender et al., 2014; Hintz and Tyson, 2015; Franke et al., 2015; Webb et al., 2014; Murta et al., 2017)</p>	<p>The mathematical curriculum at my school incorporates student mathematical discourse during the lesson. Some of the teachers in my school follow this instructional practice by including a variety of student discourse during the lesson while other teachers have limited student mathematical discourse during the lesson.</p>	<p>I recommend that the district provides professional development training on how mathematical discourse in the classroom impact student mathematical comprehension and understanding. In addition, instructional coaches and principals should require teachers to support student mathematical discourse during the lesson by students sharing their work and classmates asking questions about their peers’ work.</p>

<p>Research has suggested that the teacher instructional practice of student-centered versus teacher-centered learning has shown to improve students' mathematical comprehension and learning (Lerkkanean et al., 2016; Lazic et al., 2021)</p>	<p>Most of my school follows the student-centered instructional approach during mathematics lessons.</p>	<p>I recommend that my school continues the work that it is doing. In addition, the district provides training for teachers on how to create and foster student-centered lessons. Principals and instructional coaches should provide teachers with different student-centered approaches and practices to include in the classroom.</p>
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The Use of Mathematical Manipulatives

Research suggests that the implementation and use of mathematical manipulatives positively impacts elementary students' mathematics. In the action plan below, I will discuss my literature findings on the use of mathematical manipulatives and the impact it has on students' mathematics test scores, comprehension, and engagement. In addition, I will address what practices my school is using with the implementation of mathematical manipulatives and what I suggest based on the research.

Table 2

The Use of Mathematical Manipulatives Action Table

Research	Practice	Recommendation
<p>There is a strong relationship between the variety of use of physical and virtual manipulatives on students' test scores (Silva et al., 2021; Shin et al., 2012; Liggett, 2017; Chang et al., 2013).</p>	<p>My school provides students with physical manipulatives to use during class and tests. However not all teachers in the school allow students to use virtual manipulatives and a different variety of physical such as base ten blocks, counters, etc.</p>	<p>I recommend that principals and instructional coaches require and encourage teachers to provide students with a variety of mathematical manipulatives. Teachers can create mathematical toolboxes that have a physical and virtual mathematical manipulative that students can choose from when working.</p>

<p>Physical and virtual manipulatives provide students visualization of math problems and reduce confusion (Mononen and Aunio, 2016; Silva et al., 2021; Liggett, 2017).</p>	<p>Majority of the teachers at my school encourage students to use manipulatives to represent all math problems Teachers at my school are helping students reduce confusion by encouraging the students to visual represent their math problems.</p>	<p>I recommend that teachers keep encouraging and requiring students to show their thinking and work using mathematical manipulatives.</p>
<p>The use of virtual manipulatives has increased students’ engagement in mathematical thinking and comprehension (Lister et al., 2019; Chang et al., 2013, Shin et al., 2012).</p>	<p>My school does not provide an online platform or app for mathematical manipulatives. Students are provided physical manipulatives instead.</p>	<p>I recommend that the district and school provide an online app for mathematical manipulatives that students can use during class and see if the addition of virtual manipulatives improves engagement. In addition, the district should provide a training on the virtual manipulative platform and the impact it has on students’ mathematical comprehension.</p>

Embedded Language Support

Research suggests that the implementation of embedded mathematical language support positively impacts elementary students’ mathematics. In the third action plan table below, I will discuss my literature findings on the use of embedded language support during mathematical lessons in the classroom and the impact it has on students’ mathematical comprehension. In addition, I will address what practices my school is using with the implementation of embedded mathematical language support and what I suggest based on the research.

Table 3

Embedded Language Support Action Table

Research	Practice	Recommendation
<p>There is a strong relationship</p>	<p>My school is implementing</p>	<p>I recommend that the schools</p>

<p>between students’ reading skills affecting their mathematical skills and comprehension (Hadianto et al., 2021; Fuchs et al., 2021; Hamidi et al., 2024)</p>	<p>what the research suggests. The school focuses more on reading intervention groups rather than mathematics intervention groups because they have recognized how reading skills impact mathematics skills.</p>	<p>continue to implement a schoolwide reading intervention for all elementary grades. In addition, teachers could require a home reading log for students to encourage students to read outside the classroom.</p>
<p>Research has demonstrated the use of storybooks in mathematical classrooms have shown to impact students’ mathematical comprehension and academic vocabulary understanding (Hassing-Das et al., 2015; Casey et al., 2008)</p>	<p>My school does not use mathematics storybooks in classrooms to support students’ academic vocabulary and understanding.</p>	<p>I recommend that the district provides physical and virtual mathematics storybooks to classrooms that align with the curriculum. In addition, principals and instructional coaches provide teachers support with implementation of mathematical storybook in lessons and in the classroom.</p>
<p>Teachers explicitly teaching and facilitating mathematical discourse by implementing visuals and academic language in the classroom has shown to positively impact students’ mathematical language and comprehension (Moffett and Eaton, 2019; Byrne and Prendeville, 2019; Luevano and Collins, 2020)</p>	<p>Majority of the teachers at my school include mathematical student discourse during lessons. Only a few teachers explicitly teach and provide visuals on what productive mathematical discourse looks like and sounds like.</p>	<p>I recommend that teachers provide visuals on productive discourse and also demonstrate what mathematical discourse looks like and sounds like in the classroom. In addition, the district should provide trainings on how teachers can facilitate and support mathematical discourse in the classroom. The district should provide a visual on what academic discourse sounds like and looks like, so students and teachers have a resource to reference.</p>

Summary

As seen in the action tables above, there are a few specific mathematical teaching practices that have shown to positively impact elementary students' mathematical comprehension than others. In this section we looked at the recommendations from the literature on mathematical teaching practices and analyzed how a school in the Puget Sound area's practices reflect those recommendations. I will now return to the questions in the rationale and examine the literature more closely in attempt to answer them in the discussion section.

Discussion

The purpose of this project is to explore the research on effective mathematical teaching strategies that impact elementary students' mathematical comprehension. Throughout the peer reviewed literature, three themes aroused on teaching practices that impact mathematical comprehension which were the use of mathematical manipulatives, teacher instructional moves and practices, and embedded language support.

In this section, I will discuss my finding from the literature review that addresses the guiding questions and purpose of this project.

- According to the research, what teaching practices are most impactful on mathematical comprehension?
- According to the research, how does classroom climate impact student learning and comprehension?
- According to the research, what challenges do teachers have in current schools for implementing effective mathematical practices?

In addition, I will address implications for future teachers, students, and schools, implications for future research, and the limitations of the project.

Discussion of Findings

In this section, I will answer the questions that came up during my literature review: what teaching practices are most impactful on mathematical comprehension, how does classroom climate impact student learning and comprehension, what challenges do teachers have in current schools for implementing effective mathematical practices? In addition, I will address how mathematical teaching practices differ by grade level in terms of the research.

Most Impactful Teaching Practices

The first question I will be addressing based on research and my experiences is what teaching practices are most impactful on mathematical comprehension. I am going to use how the research answered this question and how my school approached this question and compare the differences.

According to the research, there are two teaching practices that research has shown to be the most impactful on mathematical comprehension than others. One teaching strategy that multiple studies supported was students use of virtual and physical mathematical manipulatives during math lessons and tests (Silva et al., 2021; Shin et al., 2012; Liggett, 2017; Chang et al., 2013). Mathematical manipulatives bring hands-on learning to the classroom that meets the diverse learning needs of all students. The use of manipulatives promotes deeper mathematical understanding and increases students' comprehension of mathematical concepts. Students use of manipulatives have shown to positively impact comprehension and improve test scores. (Silva et al., 2021; Shin et al., 2012; Liggett, 2017; Chang et al., 2013).

Based on my experience working and teaching lower elementary students, mathematical manipulatives has limited learning confusion for students mathematical learning. Students are able to demonstrate their knowledge and represent the problem physically and manipulate it to find the answers. Manipulatives help students understand the

steps they are taking to solve a problem and why they are taking those specific steps.

Student teaching in first grade last year and teaching first grade this year, I have witnessed students mathematical understanding through the use of manipulatives and without the use of manipulatives. The use of manipulatives limits confusion for students and creates mathematical academic discussion with peers.

However, the research did not specify which virtual or physical manipulatives were the most impactful on students' mathematical comprehension. The studies address students' mathematical understanding and test scores with and without mathematical manipulatives. Although research findings indicate the use of virtual and physical manipulatives is the best practice, my district does not provide virtual manipulatives. This is possibly due to the following reasons that physical manipulatives are present in the classroom and the district has not adapted an app that allows students to use virtual manipulatives as a tool in the classroom.

Another impactful teaching practice is the facilitation of mathematical discourse in the classroom. Multiple studies demonstrated that mathematical student discourse impacted and showed growth in comprehension. Examples of mathematical discourse include turn and talk, revoicing, and agree/disagree and why. Facilitating mathematical discourse changes the lesson from teacher-centered to student-centered where students are able to engage, think deeply, and make connections to their peers' ideas and thinking (Firmender et al., 2014; Hintz and Tyson, 2015; Franke et al., 2015; Webb et al., 2014; Murta et al., 2017).

The studies indicated that facilitation of mathematical student discourse is one of the best practices and my district promotes mathematical discourse by providing professional

development for teachers on how to facilitate and promote student discussion in the classroom. Based on my experiences teaching lower elementary, facilitating students' mathematical discourse and discussion takes experience and also support from other teachers and professional development trainings. I have had the opportunity to attend the professional development trainings that my district provided to promote mathematical discussion in the classroom. I believe the professional development was helpful and impactful. I had follow-up support from my instructional coach during math lessons and the district personals the next time we met to continue the professional development. Students having the opportunity to share their work and engage with each other's ideas and thinking allows students to use academic vocabulary and see a variety of strategies used to solve a problem. In addition, it strengthens students' mathematical identities because their voices and ideas are being heard and their peers are able to provide them feedback and vice versa. Lastly, correctly answering the problem is only one step to mathematics. One of the most important steps is students' being able to explain their thinking and their strategies. Mathematical discourse teaches students the steps to explain their thinking by hearing other examples and being explicit with their thinking to answer their peers' questions and misconceptions.

Classroom Climate

The second question I posed was how does classroom climate impact student learning and comprehension. Based on the research, I am going to answer this question and compare how my school approached this question.

According to several studies, there are a variety of ways to create a positive and engaging classroom climate that impacts students' learning. For instance, teachers

supporting and fostering students' engagement and participation in mathematical discourse in the classroom has shown to positively impact students' mathematical learning and comprehension (Firmender et al., 2014; Hintz and Tyson, 2015; Franke et al., 2015; Webb et al., 2014; Murta et al., 2017). Discourse in the classroom can lead to students to think deeply about mathematical concepts and ideas, expand their understanding, and build confidence in their mathematical identity. Fostering academic discourse where students' voices are heard creates a welcoming environment for students to share their ideas. As seen in Franke et al. (2015) and Webb et al. (2014), teacher facilitating academic discussion in the classroom lead to higher percentage of student engagement by students adding details to another student's work and thinking deeply about the strategies that were used. Based on my experiences, creating a classroom environment where students are welcomed to share their thinking and engage with their peers' work fosters an environment where students take risks and are not worried about making mistakes. My school site has reflected the literature by encouraging students to share their work and the curriculum incorporates partner and whole class sharing.

In addition, how teachers present the material and ideas is part of the classroom climate and can impact students' mathematical comprehension. Studies have shown that the use of teacher's visual to spoken word connections has increased students' mathematical comprehension and understanding of the material (Congdon et al., 2017; Swanson et al., 2015; Henderson Pinter et al., 2018). Every student has their own learning needs, and it is important that teachers use a variety of different strategies in the classroom to address those needs. Not every student learns and comprehends material the same. Some ways to present mathematical materials is by having visual posters throughout the room with labels and

pictures, connecting spoken word to hand gestures, and hands on manipulatives. In Henderson Pinter et al. (2018), the research demonstrated that making explicit connections to material and physical objects with spoken word reduced confusion and misconceptions for students.

Based on my experience working in elementary education, fostering a classroom climate that meets the learning needs of all students encourages engagement which impacts students' comprehension. For instance, my school site allows students to choose mathematical manipulatives that best fit their learning style. This allows students to choose strategies that work best for themselves and demonstrates that there isn't just one strategy to solve mathematical problems. In addition, classrooms create visual anchor charts that serve as resources and reminders for students on what they are learning in the classroom so that the goal and objective is clear. Students play a part in their learning and classroom environment. Lastly, connecting hand gestures to spoken word has helped students who are visual and auditory learners and creates a fun learning environment. One way my school site uses this strategy is by having students clap their hands together to represent a group of ten.

Challenges for Implementing Mathematical Teaching Practices

My third was "what challenges teachers have in current schools for implementing effective mathematical practices?" Here I look at how the research answered the question and how my school approached this problem and analyze the differences.

According to multiple studies, there could be challenges for implementation of mathematical teaching practices in schools to impact elementary students' mathematical comprehension. The first challenge that schools could face is the cost of implementation.

Physical and virtual mathematical manipulatives have shown to positively impact elementary students' mathematical comprehension and reduce confusions (Mononen and Aunio, 2016; Silva et al., 2021; Liggett, 2017). The use of virtual manipulatives requires students having access to an electronic device where they can access a virtual manipulatives app. The cost of giving each student an electric device and having access to a virtual manipulative app can be expensive and can impact students on implementing these teaching practices. School districts will have to pay for licensing of the different virtual programs and hire staff to maintain the program and the electrical devices. Also, physical manipulatives can be expensive which mean districts and schools can limit the variety of manipulatives in each classroom. There is also maintenance cost to continue the use of mathematical manipulatives. For instance, physical manipulatives get lost or worn throughout the year so there needs to be funds to replace them each year otherwise the tool isn't as useful if there is an incomplete set. If schools only purchase new manipulatives every few years and teachers have to make do with what they have this brings up an equity challenge.

In addition, another challenge for cost of implementation is the district and schools providing professional development trainings to teachers on the effectiveness of mathematical manipulatives and how to foster academic discourse in the classroom. Multiple studies demonstrated that teachers supporting academic discourse in the classroom impacts students' comprehension (Moffett and Eaton, 2019; Byrne and Prendeville, 2019; Luevano and Collins, 2020). Polly (2015) conducted a study on the effects of professional development on students' mathematical comprehension. The teachers who participated in the study showed growth in their teaching and provided a student-center approach to their teaching rather than a teacher-center

which increased student engagement. The professional development provided teachers with strategies and examples of support moves that can be used in the classroom to impact students' mathematical comprehension such as use of manipulatives and facilitating the communication of mathematical ideas. Providing teachers with trainings can be expensive for school districts because teachers are being paid for their time. Also, there is a limit on how many teachers can attend each training so depending on how many trainings the district provides it can limit access to teachers in receiving the same support.

Regarding the implementation and access of mathematical manipulatives, my school provides a variety of physical mathematical manipulatives to every classroom. However, some teachers buy more variations of manipulatives using their own money. The school district and my school does not provide teachers and students with a virtual manipulative app. Students use physical manipulatives when working with mathematical problems. In addition, regarding professional development trainings, my school district provides access to a variety of mathematical trainings for teachers. There is a variety, so it allows each access to different trainings. During the school year, my school provided the first-year teachers a once of month math training in the morning to discuss how to support and foster mathematical discourse in the classroom. During this training, teachers were taught different teacher support moves and strategies and also had the opportunity to discuss with their coworkers what techniques they are using in their classroom to impact students' mathematical comprehension.

According to the research, my school's practices are aligning with majority of the recommendations. For instance, my school provides mathematical manipulatives to all classrooms and teachers are willing to share manipulatives with their colleagues to support each other's students' learning. However, my school does not provide students with the access to

virtual manipulatives. Students have access to laptops but there is no virtual app to use manipulatives during class or tests. In addition, my school aligns with the research because it provides teachers with growth opportunity by having professional development trainings on mathematical discourse and other areas. The district does a great job providing access to all teachers and not limiting attendance.

Difference by Grade Level

In addition to addressing the three questions above, I will address how mathematical teaching practices differ by grade level. Here I will look at how the research answered the question and how my school approached this problem and analyze the differences.

According to the literature, one mathematical teaching practice that differ by grade level is academic student discourse in the classroom. Kindergarten or first grade student discourse looks different than fourth grade discourse. For instance, upper elementary students are more independent and need less support with academic discussion between their peers. Jacob and Empson (2015), Hintz and Tyson (2015), and Webb et al. (2104) all presented research on student mathematical discussion in the classroom. However, the participates involved from all three of these studies varied by grade level. The teachers that were part of these studies facilitated academic discussion by posing general starter questions to students, facilitated students' explanations, encouraged students to use other strategies, and connected student's' thinking to symbolic notation. The upper elementary classrooms demonstrated a student-center approach rather than a teacher-center approach. Teachers are still facilitating and supporting academic discussions with less explicit directions by stepping back when discussing solutions and allowing the students to lead the discussions and explain their strategies.

Murata et al. (2017) and Firmender et al. (2014) conducted research where the participants were students in grades kindergarten through second. The teachers that were part of these studies fostered academic discussion by engaging students in verbal communication in math and encouraging the use of appropriate math vocabulary by implementing think time, agree/disagree and why, partner talk, repeat and check, and add on. In the lower elementary grades, teachers still created a student-center classroom approach, however the discourse was prompted more and structured more tightly by teachers explicit teaching of what academic discourse looks and sounds like.

In addition, another mathematical teaching practice that differs by grade level is the implementations of storybooks to support academic vocabulary and comprehension. Casey et al. (2008) and Hassinger-Das et al. (2015) both investigated literature on the impact of mathematical picture books on students' mathematical comprehension and vocabulary. The participants included kindergarten and first-grade students. This teaching practice is recommended for kindergarten through second graders rather than third through fifth graders. Younger students tend to enjoy picture books than older students and are more grade appropriate.

My school aligns with the research in promoting mathematical academic discussion throughout all grade levels. The teachers at my school pose general starter questions to students, facilitate students' explanations, encourage students to use other strategies, and connect student's' thinking to symbolic notation. However, based on my experience teaching lower elementary, lower elementary teachers are explicitly teaching academic discourse and help facilitate the conversation between students more than upper elementary. In addition, teachers are implementing think time, agree/disagree and why, partner talk,

repeat and check, and add on techniques to help support academic discussion. In comparison to the research about implementation of picture books to promote academic vocabulary and comprehension, lower elementary teachers at my school have not been using this teaching strategy.

Implications for Future Teachers, Students, and/or Schools

To implement impactful mathematical teaching practice that support elementary students' comprehension, there are actions that teachers, schools, and districts need to take. First, school districts need to be providing teachers with professional development trainings that support impactful mathematical teaching practices and how to implement them in their classrooms. One specific professional development training that districts should be providing is how to foster mathematical student discourse in the classroom and supporting a student-center rather than a teacher-center classroom. During this professional development, the district provides teachers with specific support moves that help students' discussions such as partner talk, individual think time, revoicing peers' ideas, and agreeing and disagreeing. Then, teachers are implementing these techniques and strategies into their lessons where they are receiving feedback from the district and principal.

Another professional development opportunity the district should provide is the impact mathematical manipulatives have on students' comprehension. School districts should support teacher in the implementation of physical virtual manipulatives in their classrooms. The use of virtual manipulatives requires school districts to have a virtual site that students and teachers have access to the manipulatives during lessons. In addition, school districts and schools should provide classrooms with the physical manipulatives that

students need to understand the information they are learning and demonstrate their thinking.

To support the implementation of impactful mathematical teaching practices, teachers need to attend the professional development trainings the districts provide, and schools should encourage teachers to attend. The district can encourage teachers to attend by creating the professional developments during contract hours such as late start Wednesday's and also provide teachers with subs if it is during the day. In addition, teachers should use the research of mathematical manipulatives and academic discussion in their classroom and try their best to implement these techniques into their classroom. Teachers have the ability to reach out to their districts and schools for support in these mathematical teaching practices, so their students are supported.

Implications for Future Research

Experimental research is needed to compare schools and school districts that provide professional development trainings to teachers and staff on impactful mathematical teaching practices. The professional development trainings should include implementation of virtual and physical mathematical manipulatives, supporting academic discourse, and use of other resources in the classroom. Additional studies should explore the use of virtual and physical mathematical manipulatives. Research needs to investigate what specific physical mathematical manipulatives are most impactful based on grade level and curriculum and what online platform is best for students to use virtual manipulatives. In addition, the studies need to provide more specific teacher support moves to foster academic discussion and compare certain teacher support moves to one another.

Limitations of the Project

This literature review contained studies from 2008 to 2024. When looking for research, I tired limiting to only the last ten years but realized I needed to make the publication date broader. The key words that I used when finding studies were mathematical teaching practices, elementary math instruction support, elementary mathematical comprehension, and instructional practices on students' mathematical comprehension. My research only included participants from kindergarten through fifth grade. I excluded studies whose participants were above fifth grade. All the research was conducted in a classroom environment involving more than one participating classrooms in the study either as the control group or experimental group.

One personal limitation that impacted my research was that I was a first-year teacher this year which limited my ability to go to the library to look through research. All my studies were found on online databases and majority of the studies were found on the University of Washington Library online database. Learning how to be a first-year teacher took away from how much time I wanted to put into my research time and focus.

Conclusion

Mathematics is present in every aspect of students' lives, not just in the classroom. Mathematical teaching practices have been demonstrated in research to be critical in supporting and developing students' mathematical learning and comprehension. These research practices give teachers strategies and techniques to implement into their classroom to help students reach learning goals and their learning needs. Also, these practices engage students in their learning to support student-led learners. According to OECD (2023) the United States ranked below the PISA average in mathematics and is lower than the average twenty-one education systems. In this review I have tried to address this crisis by presenting

different mathematical teaching strategies that research has demonstrated to impact elementary students' mathematical comprehension.

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