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The Effects of Math Warm-ups on a Student's Number Sense

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Chapter 1: Introduction

Students who are consistently, severely discrepant from their peers in the general education math setting are often brought to the district problem-solving team to find a solution to their lack of progress. At that time, it is determined whether that student is evaluated for special education services or provided an academic intervention. I work specifically with students in a resource room setting that uses an alternate curriculum moving at a slower pace. What I have found is that many times students that are in these classes have poor number sense. Number sense is a very broad term that can be broken down many different ways but throughout this starred paper I would like to focus on whether students can complete addition, subtraction, multiplication, and division problems mentally or whether they need paper using the standard algorithm. I am also interested in seeing how students are verbalizing their work.

The purpose of this starred paper was to review the literature regarding different teaching or warm-up models as well as finding out which model is the most effective. I am particularly interested in how this affects the secondary math students I teach. In Chapter 1, I briefly summarize the research questions, what the focus of those topics will be throughout the paper, and the importance of this topic as it pertains to my teaching. Chapter 2 identifies three different teaching methods used in math classes as well as case studies that analyze the effectiveness of each method. Chapter 3 identifies the findings in my research as well as recommendations for the future.

Research Questions

The purpose of this study was to examine any relationships between warm-up activities and students' number sense. My research questions were:

1. What types of warm-up models have been implemented for students who struggle with number sense?
2. Which warm-up method increases student number sense the most?

Focus of Paper

I have researched articles using the EBSCO resource that is offered to me as a St. Cloud State University student. In my research articles, I used the following descriptors: "Math Talks," "Number Talks," "math warm-ups," and "secondary education number sense." Students in my own classroom received a daily number talk or a daily math talk for 8 minutes at the beginning of class. A baseline was given using a grade-level Math Concepts and Applications probe and 10 minutes of work time prior to any warm-up method being implemented. The scores were then averaged by finding the mean. A grade-level Math Concepts and Applications Probe was administered once a week with 10 minutes of work time to assess student progress.

Importance of the Topic

I frequently see middle school special education math students struggle to learn new concepts due to their poor number sense. When students are aware of the relative position of numbers, they can develop linear representations of these numbers, such that each number is one more than the one that comes before it and one less than the one that comes after (Siegler & Booth, 2004). On the other side of this, when a student lacks number sense, it makes learning advanced concepts more difficult and the students fall farther behind each day. This is concerning because students that are in a special education resource math class are expected to make greater progress than their peers so that that they can eventually be put back into the mainstream math class.

The research and findings from this paper will affect my teaching and daily routine. Colleagues of mine are implementing a "math talk" (Hufford-Ackles, Fuson, & Sherin, 2004) or "number talk" (Parrish, 2010) daily exercise for the first 8 minutes. The intention of the number talk is to increase a student's number sense by getting them to solve problems without using the standard algorithm by verbalizing their answers and participating in class discussions. It is key to focus on number relationships and use these relationships to develop efficient, flexible strategies with accuracy (Parrish, 2010).

Definitions

Number Talk: teacher-facilitated solving of short problems that is led by students discussing their thinking. The goal of a number talk is to increase a student's number sense while listening to others explain their thinking.

Math Talk: teacher-facilitated and teacher-lead solving of a problem. The goal of a math talk is to use a student's number sense and apply it toward solving a problem a specific way.

Number Sense: understanding the relationship between numbers and being able to perform mental math with single digit addition, subtraction, multiplication, and division problems.

Revoicing: teacher tries to repeat some or all of what a student has said and then asks the student to respond and verify whether the teacher's statement is correct.

Standard Algorithm: a systematic process of solving a problem.

Decomposing Numbers: the process of breaking numbers down into their sub parts, which are their tens and ones.

Chapter 2: Literature Review

The purpose of this literature review was to identify different teaching methods that are used in math classes. Some of those teaching methods include: Response to Intervention, Number Talks, and Math Talks. Chapter 1 discussed the background information for the two research questions, the definition of critical terms, as well the importance of the topic and how it pertains to my teaching. Chapter 2 has three sections that contain studies of how each teaching method is implemented as well as a review of how effective that method was.

Response to Intervention

Response to Intervention (RTI) is a method of teaching that provides students with different tiers of support. According to Fisher and Frey (2011), the process starts by screening students that are currently receiving high quality instruction in the general education classroom. Struggling learners are then provided interventions that vary in intensity depending on their need. Student progress is monitored to determine the learning rate and current level of performance of the student. This data is used to determine the duration and intensity of the intervention that the student receives which is personalized for each individual student. Depending on the duration and intensity, students are categorized into three different tiers of support: Tier 1, Tier 2 or Tier 3.

Tier 1 is considered a school-wide effort to prevent students from struggling in certain areas. In Tier 1, students receive high-quality instruction that is scientifically research-based and taught by qualified personnel. This ensures that students are not struggling due to inadequate instruction. Students are screened regularly to determine their academic and behavioral baseline. This also helps determine which students are struggling with and what additional support is

needed. Students that show a need are given supplemental instruction during the school day in the regular classroom. The duration of Tier 1 instruction can vary but should not exceed 8 weeks. During this time student progress is closely monitored using curriculum-based measurements or some other type of scientific research-based screening system. If students make significant improvement, they are returned to the regular classroom but students that do not make adequate progress are moved to Tier 2 where they receive targeted interventions. Tier 2 provides students with intensive instruction where group size, frequency, and duration vary depending on need but are generally taught in a small group for one grading period. Services are provided in addition to instruction in the general education setting. Similar to Tier 1, student progress is regularly monitored. Students that show significant growth return to Tier 1; however, students that do not show adequate progress are moved to Tier 3. Tier 3 provides students with individualized intensive interventions that target the specific area that the student in struggling. If a student does not make the desired level of progress, they are then referred for a comprehensive special education evaluation where the data collected throughout the RTI process is used to help make the eligibility decision. According to the Individuals with Disabilities Education Improvement Act of 2004 (IDEA 2004), parents may request an evaluation at any time during the RTI process but waiting until a student progresses through each step helps prevent students from being misidentified as learning disabled.

Fisher and Frey (2011) researched how effective the RTI model was in a secondary school by looking at how it affected their student achievement scores. They also recorded how they organized and delivered RTI in the high school setting. After their research, they created five main focal points for implementing RTI at the secondary level. Those focal points were

focused on quality core instruction, use course competencies to monitor progress, schedule interventions to supplement, not supplant, core instruction, dedicate resources to support intervention efforts, and adopt a school wide approach to RTI to maximize intervention impact. The quality core instruction that they focused on started with frequent modeling, providing guided instruction, providing productive group work time, and giving students independent learning tasks. During this step, teachers struggled most with giving more productive group work. Based on the research of Fisher and Frey (2011), at first over 80% of class time was spent with no student-to-student interaction. By the end of the study, most classes had increased that number to over 50%. The second focal point was using course competencies to monitor progress. Through the process teachers ended up assigning homework no points and creating an assessment that is based off state standards called competency tests. If a student receives less than 70% on their competency test, they must retake it until they receive a passing grade. The catch with homework being worth no points is that students can only retake a competency test if they have no missing assignments and have completed all of the in-class work. This makes homework and in-class work practice for the competency test. The third focal point was to schedule interventions to supplement, not supplant, core instruction. Once the school implemented competency tests as the progress monitoring system, teachers were able to group students that had similar needs and instruct that group for that need rather than guessing or simply moving on. Teachers often grouped students during their "office hours" which were held just after lunch for 20 minutes or after school. Any student that was failing a class was required to attend office hours or after school session and receive additional help. The fourth focal point of implementing RTI in secondary schools was dedicating resources to support intervention

efforts. In the second year of the study, a reading specialist was released of her regular duties and given the responsibility to coordinate all of the supplemental and intensive intervention efforts. This teacher was responsible for identifying the students in need of supplemental interventions, coordinating the after-school program and giving assistance to teachers that need help creating resources. The final focal point of implementing RTI in a secondary school is adopting a school wide approach to RTI to maximize intervention impact. This was done by utilizing all staff members in the building as intense interventionists. Each teacher in the building was responsible for providing a student an intervention at some point throughout the school year regardless of the content area. This helped take some of the burden off the English and Math departments and kept students from hearing the same message repeatedly.

According to Fuchs, Fuchs, and Compton (2010), the RTI model in secondary education looks much different from the one implemented at the elementary level. The article looked at three main assumptions of RTI that may not apply at the secondary level. The first assumption is that in elementary school, screening is required to identify risk before academic deficits materialize. Many elementary students that are screened move on to Tier 2 due to their inexperience with formal testing rather than their lack of content knowledge. This creates a false positive and floods Tier 2 with students that do not have an academic deficit. When this happens, resources are stretched thin and the quality of the instruction is lowered. At the secondary level, academic deficits are well established. Students have many years of data collected to help appropriately place them in Tier 2, which reduces the chance of the false positive. Since the areas of struggle for students are well established it makes little sense to waste resources on screening a large population of students to find the few that need additional

assistance. Instead Fuchs et al. (2010) recommended teachers nominate students for Tier 2 using their knowledge of the student and the existing data. The second assumption that may not apply to secondary schooling is determining responsiveness to less intensive levels of the prevention system is required to identify students who need services that are more intensive. When students in the elementary level are identified with a deficit, they move to Tier 2 where a small group intervention is applied and if results are not satisfactory then they move to Tier 3 where an intensive intervention is applied. The model proposed by Fuchs et al. (2010) is to flip that model upside down. Since student deficits become more prevalent and larger as students get older, it makes more sense to apply immediate intensive interventions and then move students to a less intense small group when adequate results are obtained. This also helps with student motivation. By the time a student is in middle or high school, they are well aware their deficits have low motivation in those areas. This makes less intense interventions less likely to work. The third and final assumption about RTI that may not apply to secondary schools is that the nature of effective intervention is the same across the grades. It is very likely that adolescents are going to require different instructional emphasis and strategies. Since deficits grow larger with time, an elementary student that struggles with reading comprehension will require different intervention strategies than that of a middle or high school student. By the time a student gets to middle or high school, their overall issue with reading comprehension is likely much more complex than that of an elementary student.

Number Talks

For many students, math is just a series of rules and procedures. Parrish (2011) used an example of a third-grade student named Mary who was given the problem 12 minus 5. The first

thing that Mary does is cross out the 1 and record a 0 above it. She then crosses out the 2 and records a 12 above it. When questioned why she did the problem this way, Mary replied, "Because you have to do it that way when the bottom number is bigger than the top number." This is a classic example of how students see math. They do not understand why they need to do the procedures they are taught, and they do not understand where certain rules come from. The intention of Number Talks is to assist students with more accurate, efficient, and flexible strategies. This happens through modeling and practice for 8-10 minutes each day until students understand how to decompose numbers.

According to Parrish (2011), for teachers that are implementing a Number Talk into their routine there are five key components they need to keep in mind: classroom environment and community, classroom discussions, the teacher's role, the role of mental math, and purposeful computation problems.

In order for Number Talks to be successful, the teacher must create a safe classroom environment that is open to students sharing their thinking. Oftentimes when a student is explaining their thinking, and they make a mistake the teacher jumps in to correct the mistake. Teachers need to let students make mistakes and give them time to realize their mistake through their explanation of their solution. If the student still does not find their mistake, give time for their peers to find it or pose a question such as: "Is there anyone that got something different?" Oftentimes when there are mistakes, it is due to a common misconception that the whole class might have which could lead to a great discussion.

Classroom discussions is what Number Talks are all about. They get students talking about their thinking, explaining why they solved a problem a certain way, and asking questions

of their peers as to why a specific strategy was used. Number Talks start with a teacher putting a problem on the board and giving the class time to solve it mentally. When a student solves the problem, they put a closed fist on their chest and put up one finger. They then try to use other strategies to solve the same problem and put up additional fingers if they find another strategy. This gives students that are more advanced supplemental work to push themselves while still allowing struggling learners an opportunity to solve the problem. When the teacher sees that most of the class has solved the problem using at least one strategy, they call for answers and write them all on the board. Once this is done, students get the opportunity to explain their thinking to the class. In a typical classroom, students rarely get the opportunity to discuss math and are often asked to only show how they solved a problem. In a Number Talk students try to explain their thinking as best they can while the teacher writes exactly what the student says. The teacher should not assume anything. After a couple students explain their thinking, the class is then encouraged to ask each other questions. This part provides the most productive instruction.

The traditional approach to teaching according to Bishara (2018), is a teacher standing in front of the room talking to a classroom full of students and expecting them to learn. The teacher instructs everyone uniformly with no regard to the differences between them. The curriculum structure is fixed and dictated to the pupils by those who create the standards. A Number Talk is similar to the effect where teacher stands in front of the room but rather than talking to the students and expecting them to learn, the students talk about what they were thinking and learn from each other. The teacher will facilitate the discussion asking guiding questions such as: "What were you thinking here?" or "How does the way you solved the problem relate to the way

that Jimmy solved his problem?" The teacher wants to keep the students heading in the same direction and guiding the discussion so that it flows. When teachers are asking questions, it is often best to keep the questions open-ended and regarding the process of how a problem was solved rather than what the specific answer was.

Many students go through school being taught the standard algorithm for solving addition, subtraction, multiplication, and division problems. This is oftentimes the fastest and most accurate way for students to solve these types of problems, so it becomes the sole method used. Number Talks encourages students to get away from this method and use number relationships instead. If a student is given the problem 299+299 and it is written horizontally, this encourages them to see the relationship that this is similar to 300+300 and then subtract the extra two to give you 598.

The final key component to implementing Number Talks in the classroom is creating purposeful computation problems. Before giving the class a problem to solve during a Number Talk, think of the type of skill that you want the students to work on and create similar problems. Also, come up with a list of possible solutions that the class might have for your problem, both correct and incorrect, so that you can come up with appropriate guiding questions to steer the class in the direction that you want to go.

Math Talk

A Math Talk is a discussion between a teacher and their class about a specific problem that is presented. During a Math Talk, students try to explain their thinking to the rest of the class. As explained by Chapin, O'Connor, and Anderson (2009), it is often very difficult for a student to explain the thoughts that are going through their head. Even if a student's reasoning is

sound, their explanation of their reasoning may be impossible to understand. If a student's explanation is difficult for a teacher to understand, imagine how difficult it must be for their peers. Teachers must not give up on a student when they do not understand their explanations. A key technique to a Math Talk is revoicing or rephrasing. When revoicing, a teacher restates all or part of what a student has said and then asks the student to confirm or clarify. This technique keeps the student engaged in conversation and gives them an opportunity to rephrase their initial explanation.

Another great technique for a teacher to enhance a Math Talk is by asking: "Would anyone like to add on to that?" This gives students an open invitation to express their thinking or ask questions to the person that went before them. When a teacher asks this to a class, it is very important to give an adequate amount of wait time. As discussed by de Garcia (2013), teachers oftentimes do not give enough wait time and instead answer their own questions. When wait time is given regularly, it provides think time and establishes the expectation that someone will indeed respond and the affirms teacher will wait until someone does.

Questioning is another meaningful component to enhancing classroom discussion during a math lesson which is discussed by Falle (2004). A teacher's question can give a student clarity and determine for themselves whether they are on the right track. Questions like this would include: "How did you get that? Does that make sense? Can you show the class how that works?" A teacher can also question to help a student critically think about future outcomes. These types of questions would include: "What would happen if? Do you see a pattern? Can you predict the next one?" The type of question that a teacher asks will steer the direction that the learning will go.

Chapter 3: Action Research

The purpose of this research paper was to identify different warm-up methods that are used in math classes and the effect that they have on a student's number sense. Chapter 1 provided background information on the topic as well as the importance of the topic in my teaching. Chapter 2 presented a review of three different warm-up models and how they are implemented and also contained several case studies identifying the effectiveness of each model. Chapter 3 presents findings, conclusions, and limitations to the study that I conducted in my own class as well as recommendations for further research.

Findings in My Class

In order to find out what method of warm-up was going to increase my students' number sense the most, I conducted a miniature case study using two of my own special education eighth-grade math classes in North Branch, Minnesota. Both classes were given a grade-level Math Concepts and Applications Probe with 10 minutes of work time. Scores were then averaged from each class using the mean. This is the number that was used as a baseline score for each class.

In Class 1 a Number Talk was implemented for the first 8 minutes of class every day for 15 weeks. This class consisted of nine eighth-grade special education students. All the students have a math goal in their Individualized Education Program, which indicates that their disability affects their achievement in math, which is why they are in a resource math class. The students have varying disabilities including Autism Spectrum Disorder (two students), ADHD (two students), Emotional/Behavior Disorder (one student), and Specific Learning Disability in math (four students). Four of the students are on free or reduced lunch and two students live in a

single parent home. Each week the class was administered a grade-level Math Concepts and Applications Probe with 10 minutes of work time to monitor their progress. Week 1 of Number Talks started with dot problems and identifying patterns. I showed students a series of dots and asked them how many they saw. I encouraged students to try to use as many strategies to solve the problem as possible. If they found a strategy for solving the problem, they were instructed to put a thumb up on their chest and then put another finger up for each additional strategy. I then asked volunteers to share "What did you see and how did you see it?" Throughout the next several weeks students caught on to the overall theme of Number Talks and I no longer had to prompt them to explain their thinking. By week 5, the focus of my prompting was encouraging students to ask each other questions. With no modeling, the students were able to appropriately ask each other how they used a certain strategy and were able to help each other work through mistakes that were made. Math Concepts and Applications Probe scores steadily increased each week for the first 6 weeks with a slight decrease in week 7. During week 7 there was a school-wide activity planned later in the day that many students were excited to attend. This may have attributed to lower scores that week. The class progressed from dot problems to problems focused on number grouping or decomposing. This progression began during week 8 and went until week 10 when all of the problems were focused on number groupings and decomposing. The last dip in student Math Concepts and Applications Probe scores happened during week 13. The probe was administered on Halloween Day, which may have been a distraction for students.

In Class 2 a Math Talk was administered for the first 8 minutes of each class for 15 weeks. Class 2 consisted of seven eighth-grade special education students who all have a math goal in their Individualized Education Program. The students have disabilities in the categories

of Autism Spectrum Disorder (one student), ADHD (two students), and Specific Learning Disabilities in math (four students). Five of these students are on free or reduced lunch and four of them live in a single parent home. Class 2 was also progress-monitored weekly using a grade-level Math Concepts and Applications Probe with 10 minutes of work time. The first couple of weeks of Math Talks focused on student-led conversation. Similar to Number Talks, the students were instructed to tell the class what they got for a solution and then explain how they got there. My role as the teacher was to prompt students to giving more information of the process that they used to solve problem. I never corrected a mistake that a student made while they were explaining because I did not want to stop their explanations. This also leaves the opportunity for other students to ask questions and find mistakes. The problems given to the class were relevant to current class material and spiraled previous concepts. Student scores on a grade-level math Concepts and Applications Probe increased steadily for the first 6 weeks. After week 5 the students were put into two groups and instructed to solve/discuss the problems within their group and then share with the other group. The class conducted Number Talks this way for 2 weeks and then returned to the more traditional implementation as a whole group. I made this decision because I felt that not as many students were engaging in the conversation. During this time, Math Concepts and Applications Probe scores stayed stagnant but began increasing again once the whole group method was re-implemented. There was also a large dip in scores during week 13. Similar to Class 1, this probe was given on Halloween Day which may have been a factor to the dip in scores.

The following table shows the mean Math Concepts and Application Probe scores of Class 1 and Class 2 each week for 15 weeks.

Table 1

Number Talk and Math Talk Data

	Class 1	Class 2
Week 1	3.2	3.0
Week 2	5.4	4.7
Week 3	5.1	4.9
Week 4	6.0	6.1
Week 5	6.5	6.3
Week 6	7.8	7.6
Week 7	6.9	5.9
Week 8	6.8	6.3
Week 9	7.9	7.4
Week 10	9.1	8.0
Week 11	12.2	7.3
Week 12	15.8	9.1
Week 13	14.8	7.3
Week 14	15.0	7.6
Week 15	15.4	11.3
% Growth	481%	377%

As can be seen in Table 1, both classes had some up and down weeks, but overall Class 1 had a greater growth percentage from week 1 to week 15. This data tells me that the students who received the daily number talk were able to increase their number sense more quickly than students who received a Math Talk. Both methods showed great levels of improvement.

Conclusion

In conclusion, I think that the greatest factor to increase a student's number sense is through discussion. Both Number Talks and Math Talks are based around discussion, which tells me that, regardless of the method of discussion that is brought into math, there will be a positive effect. As discussed in Chapter 2, the overall goal of a Math Talk is different from that of a Number Talk, which makes it easy to determine which one has a greater impact on student number sense. Students who struggle with number sense and have a hard time with decomposing numbers will likely benefit more from a Number Talk. Number Talks take what a student knows about multiplying, dividing, adding, and subtracting and breaks them into smaller, more familiar steps. A student who already has great number sense would benefit more from a Math Talk because of the way that a Math Talk uses number sense to complete a more difficult problem. Both Class 1 and Class 2 are special education math classes, which indicates that the students in those classes are already discrepant from their peers. It is typical for students that struggle with math to have trouble with their number sense making a Number Talk the most effective method for both Class 1 and Class 2. Math Talks are a great warm-up tool that can benefit many students but when it comes to increasing a student's number sense a Number Talk is the better option.

Limitations

This study was conducted using a convenience sample in my own class and as such should not be generalized beyond that context. Class 1 contains nine eighth-grade special education students. All the students have a math goal in their Individualized Education Program which indicates that their disability affects their achievement in math, which is why they are in a resource math class. The students have varying disabilities including Autism Spectrum Disorder, ADHD, Emotional/Behavior Disorder, and Specific Learning Disability in math. Four of the students are on free or reduced lunch and two students live in a single parent home. Class 2 consisted of seven eighth-grade special education students who all have a math goal in their Individualized Education Program. The students have disabilities in the categories of Autism Spectrum Disorder (one student), ADHD (two students), and Specific Learning Disabilities in math (four students). Five of these students are on free or reduced lunch and four of them live in a single parent home.

Recommendation

The research that I have conducted in my own classroom and throughout this literature review applies to a very small population. Something that I would like to see more research on is what types of elementary (K-6) curricula provide students with the greatest number sense. I am beginning to see more regular education students who have a very poor number sense and solve problems procedurally with no idea why the procedural method works. I believe that if students can get a strong number sense at an early age, this will help them have an understanding of why the procedural method works rather than just how to do it.

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