Examining Number Talks with Secondary Preservice Teachers

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Abstract: *This paper shares an investigation of the impact of Number Talks on secondary preservice teachers' number sense. Quantitative data was collected and analyzed regarding preservice teachers' number sense. Statistical analysis showed a significant increase in the number of strategies preservice teachers used to solve a mental mathematics problem. After experiencing Number Talks, nearly all of the preservice teachers responded that they would consider using Number Talks in their classrooms. Implications of the use of Number Talks with secondary preservice teachers are discussed.*

Keywords: *Number Talks, mathematical fluency, strategy, preservice teachers, number sense, mental mathematics*

1 Introduction

Have you ever been out in the community and seen someone reach for their cell phone calculator to solve everyday calculations such as determining a 15% tip or 20% off a clothing item at a store? As teachers of mathematics, one of our desires is to empower others to have a number sense that makes mentally performing these calculations a more efficient choice than pulling out a cell phone. Parrish and Dominick (2016) state that students should be able to use number sense to help them solve problems, determine the appropriateness of applying procedures to different problems, check solutions for reasonableness, and discuss mathematics with peers. We believe it is important for students to be able to move flexibly between different strategies. To effectively help their students develop in these ways, teachers must acquire these same attributes. In this manuscript, we describe an investigation into secondary preservice mathematics teachers' number sense via engagement in Number Talks. In many ways, secondary preservice teachers represent the many success stories of our K-12 mathematics education system. Investigating their number sense will give us insight into what we are doing well and also allow opportunities for us to reflect on ways to improve.

2 Number Talks as an Instructional Strategy

The idea of a Number Talk is a fairly new concept; it was more widely implemented in the early grades beginning in 2010 (Flick & Kuchey, 2015). According to Number Talk advocates, Parrish and Dominick (2016), a Number Talk is a "five- to fifteen-minute classroom conversation around purposefully crafted problems that are solved mentally" (p. 13). During Number Talks, students are expected to solve problems mentally, share their solution strategies with their peers, and justify their reasoning (Parrish, 2011). According to Parrish (2011), a Number Talk is characterized by five

major components: classroom environment and community, classroom discussions, the teacher's role, role of mental math, and purposeful computation problems. First, a successful Number Talk occurs in a classroom with a safe learning environment in which students feel free to share their ideas. Shared ideas are respected by their peers. Teachers can discover misconceptions in student thinking when students feel comfortable sharing incorrect solutions (Parrish, 2011). Next, students indicate their thinking via hand signals. After a teacher poses a mathematical computation, students show they are thinking by putting their fist to their chest. Then, students gradually add fingers to their hand to show the teacher how many strategies they have used to solve the given computation (Parrish, 2011). Students engage in discussions about the relationships between numbers as well as determining the efficiency of both correct and incorrect solution strategies. In addition, the teacher must act as a facilitator during a Number Talk in which he/she poses questions and listens to student reasoning. Teachers should facilitate mathematical discussions by asking students "How did you solve this problem?" rather than "What answer did you get?" (Parrish, 2011, p. 204). Also, students engage in mental mathematics during Number Talks to encourage understanding number relationships rather than memorizing procedures. Parrish (2011) notes that mental computation improves students' sense of place value. Lastly, Number Talks allow teachers to intentionally select computations that reinforce the lesson's purpose or goal (Parrish, 2011).

Number Talks can be crafted for any age, and they support discourse, mental mathematics, and calculations (Flick & Kuchey, 2015). The purpose of incorporating Number Talks into the mathematics classroom is to improve students' computational fluency (Flick & Kutchey, 2015). As the facilitator during Number Talks, the teacher should help students recognize and make sense of number relationships (Postlewait et al., 2003). Also, teachers should create a classroom culture in which all solution strategies are respected (Flick & Kuchey, 2015). Ultimately, students determine which strategy is most efficient for them (Flick & Kuchey, 2015).

3 Number Talks to Meet a Need

Postlewait, Adams, and Shih (2003) argue, "The development of number sense and computational fluency should be an integral part of the mathematics curriculum" (p. 354). They also call for learning opportunities for students to acquire a conceptual understanding of mathematics rather than simply memorizing standard algorithms (Postlewait et al., 2003). They believe, "Composition of number is the basis of computational fluency" (Postlewait et al., 2003, p. 354). According to the National Council of Teachers of Mathematics (NCTM) (2000),

> computational fluency refers to having efficient and accurate methods for computing. Students exhibit computational fluency when they demonstrate flexibility in the computational methods they choose, understand and can explain these methods, and produce accurate answers efficiently. The computational methods that a student uses should be based on mathematical ideas that the student understands well, including the structure of the base-ten number system, properties of addition and subtraction and multiplication and division, and number relationships. (p. 152)

There is a strong correlation between procedural skill and conceptual understanding (Siegler, 2003). To foster mathematically fluent students, teachers must help students "make sense of and organize number relations" (Author, 2014, p. 27). Number Talks help students develop "...more accurate, efficient, and flexible strategies" (Parrish, 2011, p. 199). As we read through the Number Talks literature, we connected its described benefits with a hope that we have for all of our fellow citizens; that they have a feeling of empowerment to use their own number sense to mentally solve reasonable and everyday calculations.

4 Investigating Number Talks

In order to study Number Talks, we started with a wondering: How does engaging in Number Talks impact preservice teachers' number sense?

4.1 Context/Participants

We co-taught a mathematics education course at a mid-sized university in the Midwestern United States. This sophomore-level course was designed for preservice teachers pursuing a degree in secondary education (grades 7-12). There were 29 preservice teachers. Throughout the course, we engaged preservice teachers in activities designed to improve their understanding of number theory, algebra, service learning, and the Standards for Mathematical Practice. For the purpose of this investigation, we also engaged them in eleven Number Talks over the course of the semester. Because it is imperative to establish classroom norms prior to engaging students in Number Talks, the following norms were negotiated as a class:

- After the prompt had been written on the board, preservice teachers placed a fist to their chest indicating they were thinking.
- Preservice teachers gradually put up more and more fingers on their hand as they thought of different strategies for solving the problem.
- Preservice teachers solved all problems mentally, unless otherwise instructed.
- Once preservice teachers determined one way to solve a problem, they searched for other, potentially more efficient, strategies.
- When classmates presented their strategies to the class, preservice teachers agreed to be respectful and strived to make connections between presented solution strategies and their own.

4.2 Class Data Collection and Analysis

First, a pre-assessment was administered to each student to assess their current number sense on a problem involving mixed numbers and multiplication. (See Appendix A.) Preservice teachers were asked to solve $36 \cdot 2\frac{2}{3}$ mentally using as many strategies as they could, to explain their thinking for each strategy, and to identify their preferred solution strategy.

Secondly, preservice teachers were engaged in eleven Number Talks facilitated by both authors. There were two types of Number Talks: six mental mathematics calculations and five "What's My Rule?" functions. For "What's My Rule?" preservice teachers were given a few x-values with corresponding y-values in a table, and they determined the function that created the specific rule. Below is a list of each of the eleven Number Talk prompts:

- $12 \cdot 13$
- $45/2.5$
- $5 \cdot 32$
- $1.25 \div 0.025$
- $2\frac{3}{8} - \frac{5}{8}$
- Determine My Rule: $y = 3x + 5$
- Determine My Rule: $y = 3x$, $y = 5x$, $y = 2.25x$
- Determine My Rule: $y = 4x + 15$, $y = 3.5x + 2$
- Determine My Rule: $y = \frac{1}{x}$, $x \neq 0$
- Determine My Rule: $y = x^2 + 3$, $y = x^2 - 4$
- Which is greater? $75 \cdot 29$ or $79 \cdot 25$

Then, a post-assessment was administered to each student to assess their number sense after engaging in Number Talks throughout the entire semester (see Appendix A). Once again, preservice teachers were asked to solve $36 \cdot 2\frac{2}{3}$ mentally using as many strategies as they could, to explain their thinking, and to identify their preferred solution strategy. However, this time, preservice teachers were also required to indicate whether they would consider using Number Talks in their future mathematics classroom.

Pre-assessments were scored in the following manner: Only strategies that would yield the correct solution were counted in the "Number of Strategies" data. This included correct strategies with complete setup/description regardless if the final solution was written on the assessment. Incomplete, incoherent, or incorrect solution strategies were not counted in the "Number of Strategies" column. If preservice teachers mentioned the use of a calculator, it was not counted as a solution strategy.

In addition, all students were asked to indicate on the post-assessment whether they would consider using Number Talks as an instructional strategy in their future mathematics classrooms. Students were asked to circle "yes" or "no" on the backside of the post-assessment. This data was then tallied by hand.

5 Findings

Sample mental mathematics strategies preservice teachers used to solve computations on both the pre-assessment and post-assessment included decomposition, converting to improper/mixed fractions, distribution, compensation, factoring, and visual representations. Figure 1 illustrates some unique solution strategies preservice teachers used on the pre-assessment and/or post-assessment.

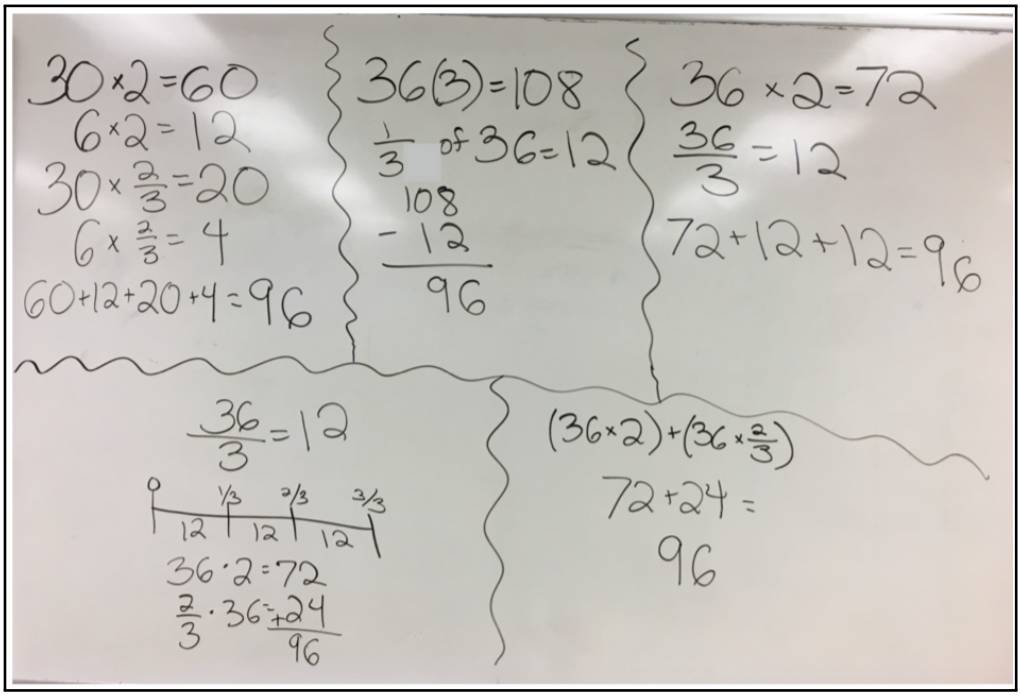

Fig. 1: *Pre-assessment and post-assessment strategies used by preservice teachers.*

Figure 2 illustrates the pre-assessment results.

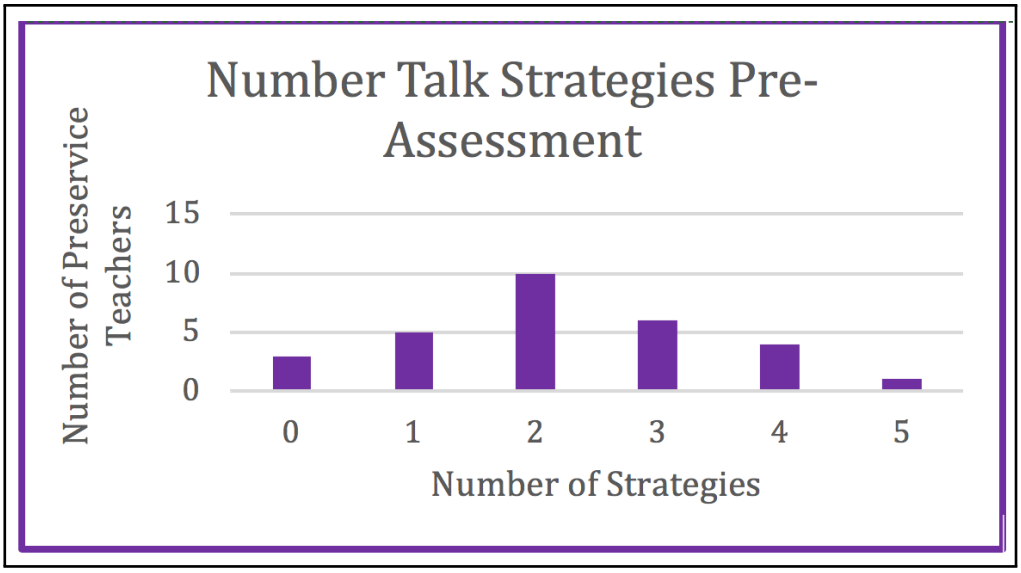

Fig. 2: *Pre-assessment results for number talk strategies.*

The average number of strategies used to complete the computation on the pre-assessment was approximately 2.2. Of those preservice teachers who used strategies that would yield the correct solution, 19/29 used the following words to describe their preferred strategy: "simpler, faster, makes most sense to me," and "easiest." The other 10 preservice teachers either had irrelevant/problem-specific reasons or had incorrect solution strategies.

Figure 3 illustrates the post-assessment results.

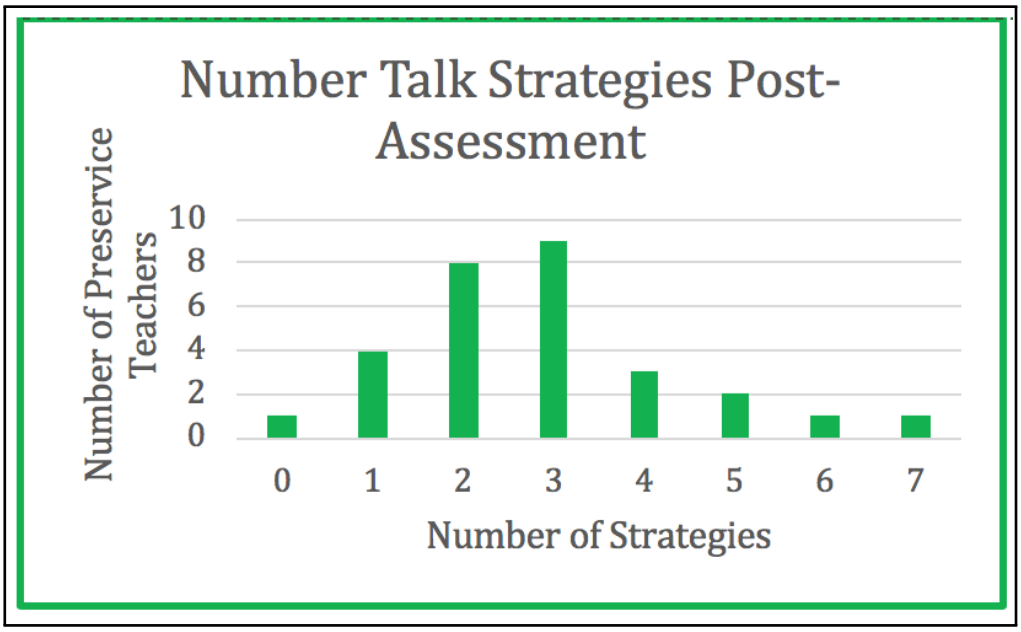

Fig. 3: *Post-assessment results for number talk strategies.*

The mean number of strategies used to complete the computation on the post-assessment was approximately 2.8. Of those preservice teachers who used strategies that would yield the correct solution, 23/29 used the following words to describe their preferred strategy: "makes the most sense to me, easiest, simplest, first way, fastest, more efficient, fewer steps," and "easier to visualize/compute." The other 6 preservice teachers either had irrelevant/problem-specific reasons or had incorrect solution strategies.

A t-test of related samples was conducted using an alpha level of 0.05. Engaging in Number Talks significantly improved preservice teachers' strategy use when comparing pre-scores to post-scores; $t(28) = 2.31$, $p = 0.014$, one-tailed. It is noteworthy to mention that the findings remain significant for a two-tailed test as well ($p = 0.028$).

Figure 4 illustrates the comparison between the number of strategies preservice teachers used on the pre-assessment and the number of strategies they used on the post-assessment. This chart is broken down by individual preservice teacher.

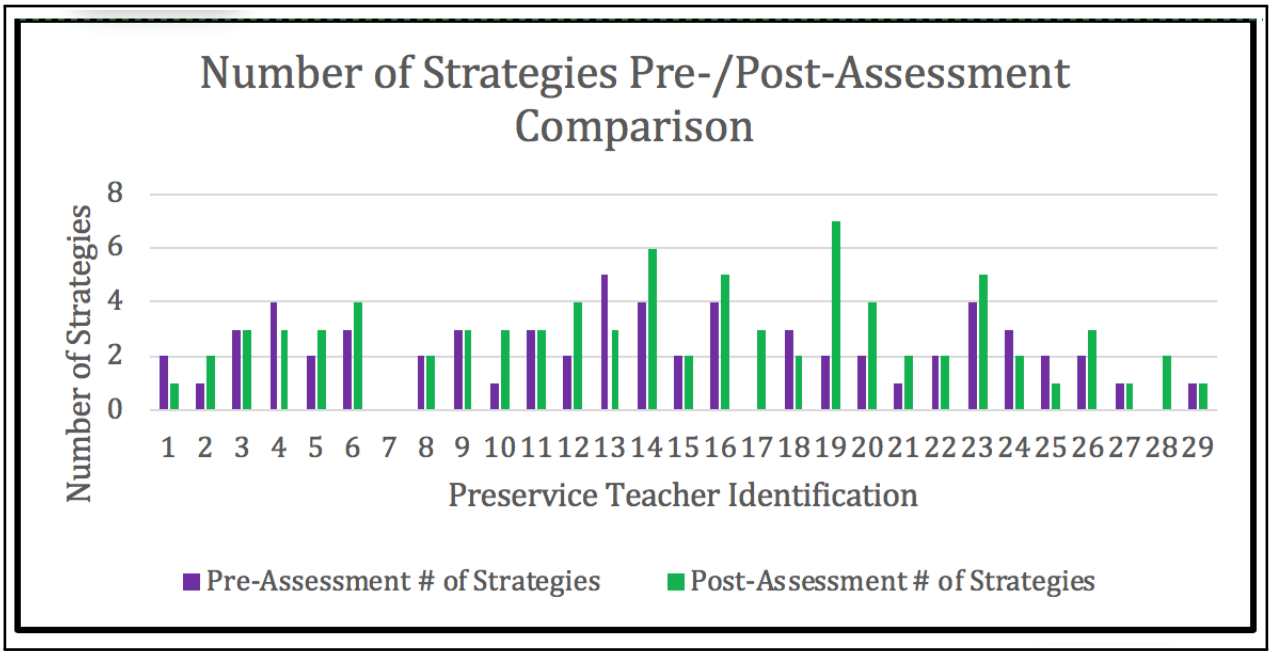

Fig. 4: *Comparison of the number of strategies used pre-assessment and post-assessment.*

Furthermore, there was a total of 28.125% increase between the number of strategies preservice teachers used on the pre-assessment compared to the number of strategies they used on the post-assessment. In total, the class increased its strategy use from 64 strategies to 82 strategies (18 total strategy increase). From pre-assessment to post-assessment, 14 out of the 29 preservice teachers (48.28%) increased their strategy use, 6 out of 20 preservice teachers (20.69%) decreased their strategy use, and 9 out of 29 preservice teachers (31.03%) remained constant in their strategy use. Figure 5 illustrates the percent change in preservice teachers' strategy use from pre-assessment to post-assessment.

When preservice teachers were asked, "Would you consider using Number Talks in your future mathematics classroom?" 28 out of 29 preservice teachers replied, "yes," and 1 out of 29 preservice teachers replied, "maybe."

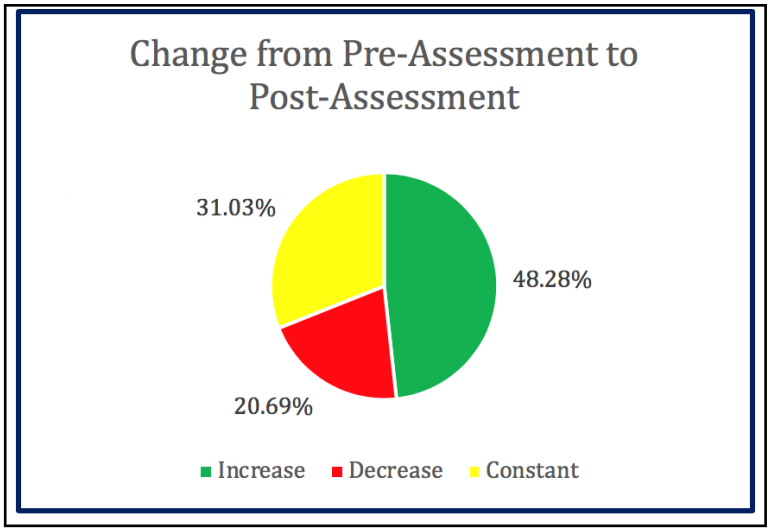

Fig. 5: *Changes from pre-assessment to post-assessment.*

6 Limitations

The investigation's sample size is small and only involves secondary mathematics education majors. The investigation focused on a type of calculation that involved multiplication of a whole number and a mixed number. The ways in which results might differ for other types of number calculation questions still needs to be explored. The findings are not meant to be generalizable but rather to act as a test case for future inquiries about Number Talks. We note that there remain other types of preservice teachers that could also take part in Number Talk investigations. Conclusions about how these results might be interpreted for use with preservice teachers studying Early Childhood or Middle Childhood Education should be approached with caution.

7 Discussion

In seeking to understand the possible value of Number Talks for preservice teachers' number sense, pre- and post- assessment data was used to draw conclusions. Preservice secondary teachers are typically a set of highly successful mathematics students from our K-12 system. Investigating the ways they think about numbers and how they benefited from Number Talks was enlightening to us as mathematics educators. Number Talks have been strongly favored among many early childhood and middle childhood teachers, as it is believed to help students grow in fluency. The investigation here, however, shows that adults, who are aspiring to be future secondary school teachers, may also benefit from Number Talks. We find this point to be something important because across a lifetime of teaching secondary students, these future professionals will likely encounter students who lack number sense. Having experiences with Number Talks and experiencing their own personal growth from them can add to their pedagogical palette to help their future students.

The findings presented here show evidence that preservice secondary teachers can grow from having Number Talk experiences in their university course work. We suggest studies that examine the issues of mathematical knowledge that might be taken for granted in the structure of teacher education programs. One such taken-for-granted structure that this investigation challenges is the notion that secondary majors do not need a formal study of number sense. More specifically, we wonder about the assumption that, if one has studied calculus and beyond, then there is no need to revisit mathematical topics that are considered "lower than collegiate mathematics." What holes or

gaps in secondary preservice teachers' mathematical content knowledge might lie under such an assumption?

Another interesting happening that some of our preservice teachers revealed came anecdotally through times of reflection. Three students mentioned that prior to the Number Talks and seeing others' ways of doing problems, they did not have any other ideas or strategies for calculating. They had always used the algorithms given to them prior to college. In addition, some preservice teachers were learning new strategies from others and began to apply those strategies during other Number Talks. We did not systematically ask preservice teachers to report these instances; however, they felt comfortable sharing this in our open classroom discussions. Throughout the semester, preservice teachers were engaged in discussions in which they worked towards identifying the significance of various "teacher moves" used by both authors. We are curious about preservice teachers' reflections regarding their own personal growth in mental computations. This metacognitive exercise may allow preservice teachers an opportunity to consider ways in which they could cultivate a classroom environment that lends itself to this type of rich mathematical thinking. We are interested in knowing more about these happenings in our future inquiries.

In future inquires, we would like to examine specific types of strategies preservice teachers use to solve mental mathematics computations, whether certain strategies are more valuable than others, and why those strategies are valuable to those who use them. Though we want to tamper our conjectures for other populations, it stands to reason that similar preservice teacher populations might also find benefits from Number Talks.

In addition, we are interested to know how engaging in Number Talks has affected the teaching practices of the 29 preservice teachers. Will these preservice teachers actually implement Number Talks into their own classrooms? Did learning new mental mathematics strategies from their peers help them to reach a wider audience of students? A longitudinal study would need to be conducted in order to answer these questions.

We also see potential applications of these research findings within the 6-12 educational setting. For example, 6-12 teachers might implement the pre-/post-assessments (see Appendix A) used in this study to formatively assess their students' use of mental mathematics strategies. To implement the assessment in Appendix A, teachers should allow students to think about the computation for two minutes without the use of any writing utensil or manipulative. Only after these two minutes should students document their thinking strategies on their papers.

Lastly, the findings from our study suggest possible benefits for K-12 educators and their students. The development of computational fluency is an important part of a student's mathematical development (NCTM, 2000; Matney, 2014). Students' computational strategies may increase with less than a dozen experiences with Number Talks, as was the case in our study. In particular, students may become more flexible and skilled in their approaches to number and their considerations of when to apply useful properties. For teachers, during the lesson planning process, we seek to anticipate student responses. Engaging in the Number Talks described in this paper may aid teachers in anticipating potential student strategies to problem-solving. Considering potential student responses and determining how to best address and connect them may lead to more effective teaching, and therefore, more effective learning.

Based on these findings, it is recommend that mathematics teacher educators incorporate Number Talks into their daily instruction when it is feasible to do so. There is evidence that doing so may not only help preservice teachers to strengthen their own number sense, but it may also help them become better teachers for their K-12 students.

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Appendix A – Pre/Post-Assessment

Take 2 minutes to solve the following problem mentally using as many different strategies as you can. **When 2 minutes have** passed, record the strategies you used to solve the problem. **Only** record the strategies you engaged in **mentally** to solve the problem.

$$36 * 2\frac{2}{3}$$

For each strategy you used to mentally solve the problem:

1) Record your thinking.
2) Explain your thought process.

If you used more than 4 different strategies, record your work on the back of this paper.
See the backside of this paper for an additional item.

Strategy #1	**Strategy #2**	**Strategy #3**	**Strategy #4**
Record your thinking.	Record your thinking.	Record your thinking.	Record your thinking.
Explain your thought process.	Explain your thought process.	Explain your thought process.	Explain your thought process.

Strategy #5	Strategy #6	Strategy #7	Strategy #8
Record your thinking.	Record your thinking.	Record your thinking.	Record your thinking.
Explain your thought process.	Explain your thought process.	Explain your thought process.	Explain your thought process.

Identify your preferred solution strategy for this problem: #_____

Why do you prefer this strategy?

*****Additional Item for Post-Assessment*****

Would you consider using Number Talks in your future mathematics classroom?

YES NO