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Effective Interventions to Improve Mathematic Fact Fluency

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Abstract

This literature review discusses the importance of mathematic fact fluency and the lasting impact it can have on student's success in the area of mathematics. Studies show that mathematic fact fluency serves as the foundation for advanced math skills. The review identifies three mathematic fact fluency interventions that educators can implement in their classroom. The research focuses on the cover, copy, compare intervention, as well as taped problems and computer-based programs, specifically Reflex. The data indicates that all three math interventions are effective in providing students with appropriate and sufficient support needed at their current academic level. Further research needs to be conducted to identify additional interventions that enhance students' performance in the area of mathematic fact fluency.

Effective Interventions to Improve Mathematic Fact Fluency

The lack of success in the area of mathematics in the United States has continued to become a nationwide concern (National Mathematics Advisory Panel, 2008). In Bob Deans' article "Math Wars Target Students, Teachers,*"* he states "There is no doubt that the math education is in total shambles" (Dean, 2007). In 2017, The National Assessment of Educational Progress (NAEP) assessed student performance in the area of mathematics at grades four, eight, and twelve in both public and private schools across the United States. The National Center for Education Statistics (2017) reported that 20 percent of fourth-grade students, 30 percent of eighth-grade students, and 38 percent of twelfth-grade students performed below proficient in the area of mathematics. According to the National Mathematics Advisory Panel (NMAP 2008) students are struggling with basic computation skills and as students' progress through school, math concepts become more difficult. For students to have success in higher level mathematic classes, they must be able to automatically and fluently recall facts, as this is a skill that serves as the foundation for future success in their mathematics education.

Mathematics fact fluency refers to the ability to recall facts in the area of addition, subtraction, multiplication, and division (Multi-Rao & Plati, 2015). Research by Poncy et al. (2006) suggests that student must also be able to accurately recall basic mathematic facts quickly and with minimal effort, a skill referred to as automaticity. However, this has been identified as an area needing more attention and emphasis in mathematic instruction (NMAP 2008). Just as decoding strategies are taught to improve reading skills, students need to be taught strategies to help improve mathematic fact fluency at the early stages of education. If students struggle with recalling their math facts, they often find other areas of mathematics too challenging and give up

because the work begins to take too long and begin to experience anxiety when expected to solve problems that they believe are too strenuous (Parkhurst et al., 2010).

As teachers are becoming aware of the alarming number of students who are unable to recall mathematic facts, they are searching for interventions to implement in their classrooms that will help increase students' ability to recall facts. The purpose of this literature review is to identify mathematic interventions that are available for teachers to implement into their classrooms that will improve students' success in recalling mathematic facts in the area of addition, subtraction, multiplication, and division.

Due to the limited knowledge and resources teachers are provided, this literature review will focus on three mathematic fluency interventions that may enhance a student's ability to accurately and fluently achieve mathematic success. They include cover copy compare, taped problems, and computer-based fact programs; all three are supported by theoretical evidence. Opposing viewpoints are presented for the following interventions in order to determine effectiveness, as well as the impact on students and teachers. The literature suggests that research should continue on these specific interventions.

Literature Review

The ability for a student to recall mathematic facts accurately and fluently is vital for their success at advanced mathematics skills. Arnold (2012) suggested that both fluency and automaticity are essential in student's mathematic success as they play a critical role in helping students succeed with problem-solving. Today many students have not yet achieved the skills required to recall basic mathematic facts accurately and fluently, resulting in additional challenges in the area of math and for some students, math anxiety. O'Connell and SanGiovanni (2011) share that, when students first begin to learn mathematic facts they are focused on the

basic computations. However, as students become automatic with simple facts, they are then able to turn their focus to other aspects of the task such as place value, decimals and fractions. When students become automatic and fluent with basic mathematic facts, their brain becomes free to focus on additional math processes. Despite ongoing attention and efforts, math deficits in basic skill fluency, computational understanding, and problem-solving skills are still evident with K-12 students (Kelley, 2008). According to the National Center for Educational Statistics, 22% of adults have not mastered enough mathematics skills past eighth grade necessary for success in many jobs (Cozad & Riccomini, 2016). In 2008, the National Mathematics Advisory Panel articulated that all students should have the necessary skills to fluently add and subtract whole numbers by the end of third grade. Developing automatic and fluency with mathematic facts helps prepare students for higher level mathematic classes in which solving multistep equations is a fundamental skill. In Codding's et al. (2011) article, the authors reiterate the importance that basic mathematic fluency has on essential life skills, adding that a necessity for individuals to successfully live independently includes basic fact fluency, which serves as the foundation for time, money, and problem-solving.

History

Since 1990, the National Assessment of Educational Progress (NAEP) assesses all students in grades four, eight, and twelve in the area of mathematics. This assessment is administered every other year to measure “students’ knowledge and skills in mathematics and students’ ability to apply their knowledge in problem-solving situations” (National Assessment of Educational Progress, 2019). As evidenced by the National Center on Education Statistics in 2017, there is a need for educators to implement research based mathematic interventions in their

classroom to help provide students with the skills needed to fluently and accurately master all mathematic facts, which will in return help with their success in higher level math classes.

Between 2015 and 2017, data show consistently low math scores in all grades across the nation. With low scores on national math assessments, the National Mathematics Advisory Panel believes "computational facility with whole number operations rest on the automatic recall of additional and related subtraction facts, and of multiplication and related division facts. It requires fluency with the standard algorithms for addition, subtraction, multiplication, and division. Fluent use of the algorithms not only depends on the automatic recall of number facts, but also reinforces it" (National Mathematics Advisory Panel, 2008).

The final report by the National Mathematics Advisory Panel indicates that elements in mathematics education are broken and not working together, resulting in under achievement of the country's values and ambitions. One of the six elements that the Panel states is not working includes that from rigorous research it should be evident how students learn. It begins by recognizing that a strong start has a positive influence for children, the benefits of conceptual understanding, fluency, and automaticity when recalling mathematic facts, and finally the effort that students put forth counts towards their achievements in mathematics (Mathematics Performance, 2008). Based on recent reports and elements determined needing further assistance, the United States Department of Education asked the National Mathematics Advisory Panel to use research to make recommendations on how to improve mathematics education for our nation. The first of the two recommendations include making it the norm in elementary and middle school mathematics curricula, that there is a clear and precise progression of mathematics learning, with attention on proficiency. The team explained that proficiency means students have a strong understanding of key concepts, master automaticity with addition and subtraction facts,

establish flexible and automatic answers that are also accurate. The second recommendation includes sufficient and applicable practice to develop fluency and automaticity with the recall of addition and related subtraction facts, as well as multiplication and related division facts. Students ability to recall mathematic facts will be beneficial to their knowledge with whole number operations (Mathematics Performance, 2008). In conclusion, the article suggested that children in the United States cannot solve single-digit addition, subtraction, multiplication, or division problems as quickly or efficiently as students from other countries (NMAPS, 2008).

With the lack of success in mathematics, our national and educational leaders are addressing the issue by implementing common core standards that directly align with mathematic fact fluency. The standards include "CCSS.MATH Content.2.NBT.B5: Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtractions", and "CCSS.MATH.CONTENT.3.OA.C.7: Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division or properties of operations. By the end of grade three, know from memory all products of two one-digit numbers" (Common Core State Standards for Mathematics, 2020). Although standards have been put in place to acknowledge the importance of mathematic fluency and the connection to later success in math, there are few curricula in the United States to provide sufficient practice to ensure fast and efficient recall of basic math facts (NMAP, 2008).

Educators are aware that mathematic fluency is important and a skill many students are falling behind in; however, there are few curricula in the United States to provide sufficient practice ensuring fast and efficient recall of basic math facts combinations (NMAP, 2008). With the lack of curricula providing support for fact fluency, educators are turning to interventions to

provide students with the support they need to successfully master their math facts. Baroody (2008) explains that there are three phases students go through to mastering basic math facts, including; counting strategies, reasoning strategies, and mastery. In agreeance with Cholmsky's (2011) article, learning new facts requires systematic introduction, specifically with the amount of numbers and the allotted time, which allows students appropriate experiences prior to further progression. Therefore, educators first need to teach the new mathematic facts prior to beginning interventions to prevent students from falling behind and using methods, such as finger counting.

Interventions

Cover, Copy, Compare

Cover, Copy, Compare is an example of a self-management intervention that is effective and efficient with the goal to enhance accuracy and fluency in basic math facts. In a recent article by Codding et al. (2011), the authors shared the five steps in the Cover, Copy, Compare intervention. The steps include "1) look at a model of the mathematics problem with the answer included, 2) cover the mathematics problem with the answer, 3) record the problem with the answer, 4) uncover the mathematics problem with the answer, and 5) compare the answer." Cover, Copy, Compare begins with training students how to perform the intervention correctly; once they are adequately trained, students are able to complete the intervention on their own allowing them to receive immediate feedback for their responses without waiting for their teachers input (Konrad & Joseph, 2013). This intervention allows the teacher to provide instruction for other students while providing them with the support they need to improve their math fact fluency. Skinner et al. (2007) researched this intervention and data shows that it is effective because it includes four key features of effective instruction including modeling, high rates of correct responding, ample practice, and corrective feedback. Konrad & Joseph (2013)

provided extra strategies that can be used to strengthen the effectiveness and efficiency of cover, copy, compare. They include providing an extra step of modeling, adding opportunities of practice for students, delivering reinforcements via teacher, demonstrating strategies for self-management, and including examples to boost maintenance and generalizations. Although research shows that all students benefit from the cover, copy, compare intervention, it is found to have an even larger impact on students with learning disabilities and struggling learners. Konrad & Joseph's (2013) advice is that when cover, copy, compare is combined with additional instructional factors, such as positive appraisal for correct responses, goal setting, or additional practice, an increase in results were seen.

Although Cover, Copy, Compare has been shown to improve students' fact fluency skills there are still challenges that teachers may face with the intervention. For example, some students may struggle with staying on task during the independent work time and end up failing to complete the intervention. In addition, with the intervention being very repetitive, students may become bored and lose interest or motivation to enhance their fact fluency using this particular intervention.

Taped-Problems Intervention

The Taped-Problems intervention are evidence-based interventions that are used to increase students' fact fluency primarily at the elementary level. According to Poncy et al., (2006) "the Taped-Problems intervention increases accuracy and fluency when used both at the individual student and group level." The intervention involves students listening to a series of recorded math facts followed by a brief pause. During the pause, students are instructed to attempt to write the correct answer before the recording reads the answer. If the student writes the incorrect answer, they are taught to cross out the answer they provided and write in the

correct answer that the audio recording read. To encourage success, there is a longer wait time between question and answer when first beginning the intervention when students are still learning their facts. Time begins to shorten as students begin to show success in answering the question correctly in the time allowed, enhancing the student's automaticity. In a recent article by McCallum and Schmitt (2011), they share three factors that contribute to the success and effectiveness of the taped-problems intervention. The factors include "numerous opportunities for accurate responding, reinforcement for correct responding and immediate feedback on responses whether correct or incorrect." In addition, Arnold (2012) explained that cognitive growth and development is promoted with less capable peers when provided with opportunities to interact with more capable peers. If these peers work together during interventions the improvements in the area of mathematic fact fluency were effective.

Data from a study by Poncy, Skinner & Jasper (2007) show that students had an increasing trend for problems answered correctly per minute, as well as the taped problem intervention taking thirty percent less time to complete in comparison to a cover, copy, and compare intervention. Due to limited evidence-based research on this intervention, additional research is needed to determine effectiveness on mathematic fact fluency.

Computer-Based Interventions

Over the past ten years, computer-based programs have become increasingly popular in providing teachers with support on increasing students' mathematic fact fluency. According to Berrett & Carter (2017) computer-based programs have the potential to a beneficial tool utilized in the classroom due to its ability to differentiate instruction to each students' academic level, provide additional opportunities for practice, and grasp students interest to increase motivation. In a report from the National Math Panel (2008), the advisory panel recommended educators

incorporate well designed computer-based software in their classrooms to help students develop math fact fluency and automaticity, one program being Reflex. Reflex leads the math education world with its research-proven methods. This particular system is an online game-based program that has the ability to individualize for each student to increase math fact fluency. Colmsky (2011) from Reflex summarizes that after students have mastered automaticity and fluency with mathematic facts, they have completed a level of mastery that allows them to retrieve mathematic facts from long-tern memory with minimal effort. This program is not to replace core instruction but to supplement fluency development.

There are four key components that make up the success of Reflex: "1) covers the complete process of fact mastery, from initial acquisition of previously unknown facts through to automaticity, 2) continuously differentiates instruction and adapts practice to each student's current ability and needs, throughout the entire session, 3) generates a fun, motivational environment for students, one that encourages frequent use and reinforces the connection between effort and success in mathematics, 4) provides educators with intuitive, insightful reports to monitor fluency gains and system usage" (Cholmsky, 2011).

In the first component, from acquisition to automaticity, students are introduced to new facts in a small set using strategies that are appropriate for their level. Some of the strategies Reflex uses to teach new facts include, the commutative property, rule-based patterns and fact families (Cholmsky, 2011). By teaching new facts using these strategies, it effectively covers all operations that will impact their proficiency in other areas of math. Once students are able to recall facts, they move into the fluency stage. This stage involves students answering open math sentences using strategies or relationships of unknown facts to known facts with no time limit due to students focusing on accuracy. After a student passes the previous stage, they move into

the third stage of practicing facts with moderate time pressure and the difficulty begins to increase. Students are shown one problem at a time and asked to provide the correct answer. As students answer questions, Reflex is monitoring their accuracy to adjust future questions based on student's current ability and providing corrective feedback as students answer questions. In the final stage, students compete in games to practice their facts, specifically fact that have been mastered and students are able to recall automatically from memory. The games are appealing to students as they use engaging graphics and sound effects, have simple rules, and progressively increase in difficulty and speed. During this stage, student's fluency continues to enhance and provides students with the sense of accomplishment

The second component to Reflex's success includes adapting instruction and practice for optimal results. Reflex has taken research-based techniques to develop fluency and customizes both the content and method of these techniques for each student (Cholmsky, 2011). Educators understand that customizing learning strategies for each student is powerful and Reflex does exactly that as students participate. Cholmsky (2011) reinforces this concept, summarizing that the Reflex program continuously monitors the responses of each student and uses that data to differentiate instruction for each student and modify practice during each Reflex session.

Students thrive on being recognized for their efforts and accomplishments. The third component does just that by setting students up for success. During the first couple of weeks students will make significant gains in their fluency and gains will continue in the following weeks. Advancements in these areas motivate students to continue the work as they see the progress they have made and are encouraged to reach new levels of the game.

The fourth and final component includes monitoring each students progress. Progress monitoring can be a challenging task for educators to complete with each student to assure that

they are progressing and modify instruction to promote success. Reflex assist with this task by "providing educators with intuitive reporting and administrative features that enable them to easily monitor progress and effectively manage their students' usage of the reflex system" (Cholmsky, 2011). Reflex provides data such as usage and progress, detailed data on current fluency levels, daily fluency growth and usage to fluency gains. This data can be used to help educators guide whole group instruction as well as the effectiveness of the intervention for every student.

Reflex (2016) did a study with one hundred thirty-nine students in grades second and third, over the course of one hundred days to compare the progress made in the area of fact fluency. The study compared Reflex to other methods typically used in the classroom setting such as timed tests, flashcards, and worksheets. At the end of the trial, students completed a posttest which scored both fluency and accuracy. The results showed that the students who received the Reflex intervention had a 140 percent increase compared to students who used other traditional interventions. Based on recent data and research it is evident that the computer-based program Reflex has the ability to successfully enhance student's math fact fluency.

Application

Incorporation of these interventions can be directly applied in the classroom setting, specifically with my role as a Title 1 math teacher. Many of my students face mathematic challenges and the repetition of the cover, copy, compare intervention and taped problem interventions would be beneficial for them. In addition, the computer-based program, Reflex, would be appealing to my students with the game-like environment. The progress monitoring and ability to modify instruction to meet the needs of each student would also be beneficial.

However, with the cost per student, it would be too expensive for small school districts to purchase.

Conclusion

This literature review identified mathematic interventions currently used in an academic setting. This topic area is important as it supports educators in enhancing student fact fluency to prepare students for later success in advanced math classes. From this review, it appears that all three interventions (cover, copy, compare, taped-problems, and computer based programs) are effective in providing students with appropriate and sufficient support needed at their current academic level.

References

Arnold, K. (2012, November 30). Theoretical Frameworks for Math Fact Fluency. Retrieved https://eric.ed.gov/?q=Theoretical+Frameworks+for+Math+Fact+Fluency&id=EJ1135680

Baroody, A. (2006). Why Children Have Difficulties Mastering the Basic Number Combinations and How to Help Them. *Teaching Children Mathematics*, *13*, 22–31.

Berrett, A., & Carter, N. (2017). Imagine Math Facts Improves Multiplication Fact Fluency in Third-Grade Students. *Journal of Behavioral Education*, *27*(2), 223–239. doi: 10.1007/s10864-017-9288-1

Cholmsky, P. (2011). From acquisition to automaticity: The Reflex solution for math fact mastery. Retrieved from https://www.reflexmath.com/images/Reflex_White_Paper.pdf

Codding, R. S., Burns, M. K., & Lukito, G. (2011). Meta-Analysis of Mathematic Basic-Fact Fluency Interventions: A Component Analysis. *Learning Disabilities Research & Practice*, *26*(1), 36–47. doi: 10.1111/j.1540-5826.2010.00323.x

Common Core State Standards for Mathematics. (2020). Retrieved from http://www.corestandards.org/read-the-standards/

Cozad, L., & Riccomini, P. (2016, November 30). Effects of Digital-Based Math Fluency Interventions on Learners with Math Difficulties: A Review of the Literature.

Dean, B. (2007). 'Math wars' target students, teachers. Retrieved from https://www.seattlepi.com/local/opinion/article/Math-wars-target-students-teachers-1225602.php

Final Report of the National Mathematics Advisory Panel. (2008). Retrieved from https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

Kelley, B., Hosp, J. L., & Howell, K. W. (2008). Curriculum-Based Evaluation and Math: An Overview. *Assessment for Effective Intervention*, *33*(4), 250–256. https://doi.org/10.1177/1534508407313490

Konrad, M., & Joseph, L. (2013). Cover-Copy-Compare. *Intervention in School and Clinic*, *49*(4), 203–210. doi: 10.1177/1053451213509484

Mathematics Performance. (2019). *National Center for Educational Statistics*. Retrieved from https://nces.ed.gov/programs/coe/pdf/coe_cnc.pdf

Mccallum, E., & Schmitt, A. (2011). The Taped Problems Intervention. *International Journal of Special Education*, *26*(3).

Musti-Rao, S., & Plati, E. (2015). Comparing Two Classwide Interventions: Implications of Using Technology for Increasing Multiplication Fact Fluency. *Journal of Behavioral Education*, *24*(4), 418–437. doi: 10.1007/s10864-015-9228-x

NAEP Nations Report Card - National Assessment of Educational Progress - NAEP. (2019). Retrieved from https://nces.ed.gov/nationsreportcard/

OConnell, S., & SanGiovanni, J. (2015). *Mastering the basic math facts in addition and subtraction: strategies, activities & interventions to move students beyond memorization*. Portsmouth, NH: Heinemann.

Parkhurst, J., Skinner, C., Yaw, J., Poncy, B., Adcock, W., & Luna, E. (2010). Efficient Class-wide Remediation: Using Technology to Identify Idiosyncratic Math Facts for Additional Automaticity Drills, *6*(2), 111–123. Retrieved from https://files.eric.ed.gov/fulltext/EJ913505.pdf

Poncy, B., Skinner, C., & Jaspers, K. (2007). Evaluating and comparing interventions designed to enhance math fact accuracy and fluency: Cover, copy, and compare versus taped problems. *Journal of Behavioral Education, 16*(1), 27-37.