Dyscalculia and Building Resilience:

An Evaluation of JUMP Math

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Mathematical Learning Disabilities

Mathematics is an important aspect of everyday life in our society. Mathematics consists of calculations, retrieval of facts, number knowledge and the application of procedural knowledge (Fletcher, Lyon, Fuchs & Barnes, 2018). Calculation is a slowly learned skill that needs to be specifically taught and is culturally derived, just like reading (Rapin, 2016). In addition, Geary (2013) states that successful mathematic computations require attention, organization and the ability to work quickly to circumvent overloading working memory stores (as cited in Fletcher et al., 2018).

Similar to reading, calculation uses complex brain circuitry (Rapin, 2016), where disorganization or disfunction can result in specific learning disabilities. The term mathematics learning disability is often synonymous with dyscalculia (Fleishner, 1994 as cited in Fletcher et al., 2018) and will be the term used for the duration of this paper. Dyscalculia can be defined as a persisting difficulty in understanding or learning number concepts, arithmetic or counting principles (Geary, 2006). Dyscalculia is experienced by a child who is otherwise competent but is failing to learn that number names refer “one-to-one, exclusively and sequentially to each item in any set of objects” at an expected age (Rapin, 2016 p.12). It has also been found that those with dyscalculia have great difficulty moving math facts into their long-term memory (Bartelet, Ansari, Vaessen & Blomert, 2014). Dyscalculia has been found to be a heterogenous disorder, meaning that there is not one cause for it (Bartelet et al., 2014).

Prevalence

In school aged children the prevalence of dyscalculia is 6%, (Bartelet et al., 2014; Fletcher et al., 2018; Geary, 2006; Mazzocco, 2001) with about 50% of these children also having issues with reading and/or attention (Geary, 2006). Children with dyscalculia display a lack of math abilities despite average to above average intelligence (Bartelet et al., 2014). While the general body of research has found no sex differences in the prevalence of dyscalculia, Barbaresi et al. (2005) found male prevalence ratios as high as 2.2:1 (as cited in Fletcher et al., 2018). This indicates that dyscalculia may be more prevalent in males than females, however further research is still required.

Deficit Skills and Subtypes

When learning mathematics working memory and cognitive control are implicated (Fletcher et al., 2018). Additionally, mathematics involves processing numbers, which are related to visuo-spatial working memory (Bartelet et al., 2014). This is important as Peng et al. (year) found that mathematical skills are correlated with working memory, especially with one's ability to solve word problems and multi-step calculations (as cited in Fletcher et al., 2018). Working memory is important for forming mental models in young children to assist in visualizing math problems (Fletcher et al., 2018). It has been recognized that further research is needed to look into how working memory affects learning mathematics, especially for those experiencing dyscalculia (Fletcher et al., 2018).

Mazzocco (2001) outlines three subtypes of math learning disabilities: semantic memory math disability, procedural math disability and visual-spatial math disability. Semantic memory math disability involves poor retrieval of math facts with response times that vary (Mazzocco, 2001). Procedural math disability involves the use of inefficient strategies for problem-solving that are often employed by younger children, displaying errors in using these strategies paired with a lack of understanding of foundational concepts (Mazzocco, 2001). Visual spatial math disability is characterized the difficulty with aligning numbers, confusion with mathematical signs, and a misunderstanding of numerical information spatially (Mazzocco, 2001). Mazzocco

(2001) found that children who are at risk for dyscalculia have profiles that show difficulties across the different subtypes. At the present time, a comprehensive screening tool for dyscalculia is not available (Geary, 2006). Despite this, Geary (2006) states that children who lack understanding of number magnitude may be displaying early signs of dyscalculia (Geary, 2006).

Longitudinal Impact of Dyscalculia

There are discrepancies between the mathematical understandings of children from middle-income families and low-income families (Geary, 1994 as cited in Siegler & Ramani, 2008). The results from a meta-analysis of six large longitudinal studies demonstrate that mathematical knowledge in kindergarten is a strong predictor of math achievement at ages 8, 10, 13 and 14 (Duncan et al., 2007 as cited in Siegler & Ramani, 2008). Results from the Siegler and Ramani (2008) study found that when low-income kindergarteners were provided with an hour (split over 15 minute sessions across a period of two weeks) to play with board games geared towards improving their numerical magnitudes, their ability to work flexibly with numbers was comparable to middle-class children. Shalev, Manor and Gross-Tsur (2005) conducted a study that further illustrated the importance of intervention, as 95% of those with math difficulties in fifth grade were still in the bottom 25% of their class when in grade 11 (as cited in Fletcher et al., 2018). Dyscalculia also impacts children in relation to levels of anxiety. Those with dyscalculia are more likely to become frustrated, leading to avoidance and increased anxiety when attempting mathematics problems (Geary, 2006). In addition to this, anxieties surrounding mathematics has the potential to lead to an increase in errors (Geary, 2006).

JUMP Math

What is JUMP Math?

JUMP Math is a Canadian registered charity offering evidence-based math resources. JUMP Math is dedicated to enhancing the potential in children by dispelling myths that only some people can be good at math and instead encouraging an understanding and a love of math in *all* students and educators. The JUMP Math approach balances discovery with feedback, scaffolding, assessment and explicit instruction that is well supported by research to be an effective practice for all learners, but especially those with learning disabilities (Solomon et al., 2019). In JUMP Math resources, concepts are broken down into small manageable steps, with the idea that as students are able to execute that step, then scaffolding incrementally to reach curriculum needs (Solomon et al., 2019). Alfieri, Brooks, Aldrich and Tenenbaum (2008) completed a meta-analysis and found that explicit instruction is not only more effective than previous methods of teaching mathematics, but that the methods used in JUMP Math (i.e. scaffolding, worked examples, explanations and feedback) reaped the most benefits for teaching mathematics to struggling students. The JUMP Math program reduces demands on both working memory and phonetic decoding to focus in on the foundational mathematical concepts (Solomon et al., 2019).

JUMP Math Effectiveness

Solomon at al. (2019) state that JUMP Math is an effective and distinct program for math instruction that is based in scientific literature aimed at improving elementary achievement in math. Solomon et al. (2011) found that children's math knowledge doubled when using JUMP Math in comparison to the incumbent program in a random sample of 272 students in a Canadian school board. Solomon et al. (2019) found that when junior students were taught using the JUMP

Math program, they saw significant gains when compared to their peers not being taught with the JUMP Math program. The early positive effects on math fluency, computational strategies and conceptual understanding persisted over time (Solomon et al., 2019). Increased math fact fluency is notable because as more math facts get stored in the long-term memory, it allows for the child's working memory (which has limited resources) to be freed up for learning other math concepts (Solomon et al., 2019). Additionally, primary students taught with JUMP Math saw significant gains in problem solving and by the second year with the program the non-JUMP Math group and the JUMP Math group showed no differences in their ability to solve problems (Solomon et al., 2019). Mighton (2006) found classrooms using JUMP Math resources progressed in the curriculum two times faster than those receiving the standard curriculum.

Math Confidence

Children with dyscalculia have not only demonstrated poorer mathematical performance but also much higher rates of math anxiety (Kucian et al., 2018 as cited in Fletcher 2018). Researchers believe that children develop negative emotions associated with mathematics from repeated mathematical failures, which is often manifested in specific math anxiety. Kucian et al. (2018) explain that individuals with MLD experience an emotional response to math-related tasks that disrupts their performance in the subject. Not only does JUMP Math prove effective in increasing math performance, but it also has been shown to have a "positive effect on student math confidence…enthusiasm…as well as a spill-over effect on confidence in subjects other than mathematics" (Mellamphy, 2004, p. 4). Increasing math confidence works to decrease math anxieties, which is of importance because anxiety can also contribute greatly to poor math performance.

The Current Project

The Learning Disabilities Association of Niagara Region (LDANR) offers JUMP Math tutoring for children in Grades 1-8 who are performing a minimum of one year behind in their math skills due to a suspected or diagnosed learning disability. With the support of an Ontario Trillium Foundation (OTF) Grow Grant, the LDANR offered twenty (20) program spots during the Fall 2019 season to assist children and youth in developing stronger social and emotional skills through a focus on specific math skill instruction and confidence-building. The children met with tutors using the JUMP Math Program two times a week for a duration of one hour, across an eight-week period.

Results and Discussion

Participant tests scores saw an increase after the implementation of the JUMP Math program. It is important to note that in the Level A (Grade 1-2) group, one participant did not participate in the post assessments, nor did one participant in the Level B (Grade 3-4) group. Not including those participants, there were 18 participants who took both the post-test and the pre-test for their level in JUMP Math. It was found that on average, after the JUMP Math intervention, test scores increased by 18%. There were a few notable differences in the cases of participants 3,4, 5,7 and 16. Participant 3 saw an increase of 67%, participant 4 saw an increase of 49%, participant 5 saw an increase of 46%, participant 7 saw an increase of 29%. Participant 16 earned a score of 84% on the pre-test, and scored 100% on the post-test. It is clear that overall, the intervention of JUMP Math increased math test scores. These effects can be seen in Appendix 1, Table 1, which provides a comparison of mean raw scores on the pre and post assessment across all levels.

Due to the small sample size, the statistical test that was run was a Wilcoxon Signed Ranks Test. This test was used to compare raw pre-test scores to raw post-test scores. The test indicated (as seen in Table 2, Appendix 1) that post-test scores were larger than the pre test scores. For level A, there was one case where the test score improved. In level B, in 10 instances participants scored higher on the post test. For level C four participants scored higher on the post test. For level D, there was only one participant, but they too saw an increase. Of the 18 participants with data analysed, 16 saw an increase in their raw score. This indicates that 89% of the participants benefited from JUMP Math as an intervention.

The second thing that this project aimed to measure was if the intervention of JUMP Math would boost confidence with math-based tasks. Along with the pre-assessment and the post-assessment, participants completed a questionnaire assessing math confidence. The post-assessment questionnaire also included the question “I enjoyed JUMP Math”, and a copy can be seen in Appendix 2, Figure 3. It was found that 95% of the participants felt that this program would be able to help them with math. Upon completion 93% of the participants felt the JUMP Math Program helped them with math. In Appendix 2, Figures 4 and 5 illustrate the difference JUMP Math has had on their confidence overall, and specifically their confidence in their abilities in math lessons. This is important because of the aforementioned impact of increasing confidence to decrease math anxiety.

Furthermore, in the questionnaires the participants completed nine questions regarding their Math Self-efficacy. They were asked on a five-point scale from strongly disagree to strongly agree and gave their responses before and after the JUMP Math intervention. The results from this can be found in Appendix 2, Figure 6. These results indicate that the JUMP Math program increased self-efficacy for participants. While all the questions can be found in

Figure 3, Appendix 2, three had notable results. Question two was “I believe I can do well on math tests”. In the pre-assessment questionnaire, 26% of participants answered strongly agree, this increased in the post test by 10%, as it was found that 36% of the participants strongly agreed that they can do well on math tests. Question three was “I believe math is important for my future” and the pre-assessment found that 70% of the participants strongly agreed, which increased to 79% on the post-assessment, seeing an overall increase of 9%. In the questionnaire, question six reads “I am not afraid to make mistakes in math class”. During the pre-assessment 30% of participants answered strongly agree, whereas in the post-assessment 43% of the participants selected strongly agree, this increase is 13%. It is clear that the JUMP Math program not only increases performance, but also math confidence.

Conclusion

The goal of the current project was to test the efficacy of JUMP Math with a sample of 20 children that have diagnosed or suspected learning disabilities. The literature indicates the program’s effectiveness in the neurotypical population, however results from this project indicate it is effective for students with learning disabilities. The project helped to increase overall math skills in addition to boosting student’s confidence in their math skills. The literature indicates the importance of math confidence in performance. It can be concluded that this program was successful in reaching these goals. There are benefits to be reaped from this program, especially those with learning disabilities who often start off at a disadvantage. This program helps to boost confidence and motivation to provide children with learning disabilities a stronger foundation to succeed in mathematics.

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Appendix 1

Table 1

Pre-Test and Post Test Scores by Level

	A Pre-Test (n = 3)	A Post Test (n = 2)	B Pre-Test (n = 12)	B Post Test (n = 11)	C Pre-Test (n = 4)	C Post Test (n = 4)	D Pre-Test (n = 1)	D Post Test (n = 1)
Mean	44.67	43.50	38.58	57.32	22.75	62.75	35.00	114.00
Median	37.00	43.50	26.00	51.00	22.50	54.00	35.00	114.00
Mode	35.00[a]	36.00[a]	16.00[a]	25.50[a]	9.00[a]	40.00[a]	35.00	114.00
Std. Deviations	15.04	10.61	31.16	28.95	12.28	28.22		
Range	27.00	15.00	92.00	102.50	28.00	63.00	.00	.00

a. Multiple modes exist. The smallest value is shown.

Table 2

Wilcoxon Signed Ranks Test

		Ranks		
Post Total– Pre Total by Level		N	Mean Rank	Sum of Ranks
A Post Total – A Pre Total	Negative Ranks	1[a]	2.00	2.00
	Positive Ranks	1[b]	1.00	1.00
	Ties	0[c]		
	Total	2		
B Post Total – B Pre Total	Negative Ranks	1[d]	2.00	2.00
	Positive Ranks	10[e]	6.40	64.0
	Ties	0[f]		
	Total	11		
C Post Total – C Pre Total	Negative Ranks	0[g]	.00	.00
	Positive Ranks	4[h]	2.50	10.00
	Ties	0[i]		
	Total	4		
D Post Total – D Pre Total	Negative Ranks	0[j]	.00	.00
	Positive Ranks	1[k]	1.00	1.00
	Ties	0[l]		
	Total	1		

a. A Post Total < A Pre Total

b. A Post Total > A Pre Total

c. A Post Total = A Pre Total

d. B Post Total < B Pre Total

e. B Post Total > B Pre Total

f. B Post Total = B Pre Total

g. C Post Total < C Pre Total

h. C Post Total > C Pre Total

i. C Post Total = C Pre Total

j. D Post Total < D Pre Total

k. D Post Total > D Pre Total

l. D Post Total = D Pre Total

Appendix 2

Figure 3

JUMP Math Survey (POST)

I am ___________

☐ bad at math ☐ OK at math ☐ good at math ☐very good at math

I do well in math lessons at school.	Yes	No
It is important for me to do well in my math lessons at school.	Yes	No
I think that this program helped me with math.	Yes	No
I enjoyed JUMP Math.	Yes	No

Math Self-Efficacy Scale

Instructions: *Now I'm going to read you some sentences about how you feel about math. You could strongly agree, agree, disagree or strongly disagree with the feelings. Do you understand? Let's try an example.*

Example: *I love chocolate ice cream.*

	Strongly disagree *(Low self-efficacy)*	Disagree	Neutral	Agree	Strongly Agree *(High self-efficacy)*
I am comfortable asking questions in math class.	1	2	3	4	5
I believe that I can do well on math tests.	1	2	3	4	5
I believe math is important for my future.	1	2	3	4	5
I think I can answer well when my teacher calls on me in math.	1	2	3	4	5
I think I can do well when I am about to take a math test.	1	2	3	4	5
I am not afraid to make mistakes in math class.	1	2	3	4	5
I often use math outside of school.	1	2	3	4	5
I believe I can reach my goals in math.	1	2	3	4	5
I enjoy doing math.	1	2	3	4	5

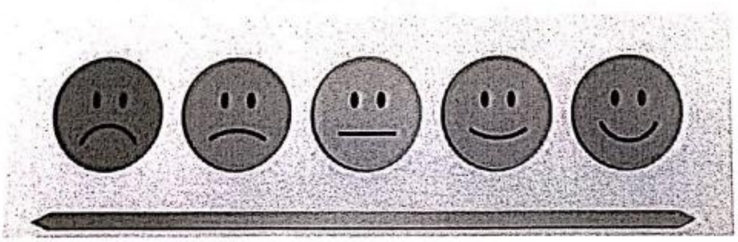


Figure 4

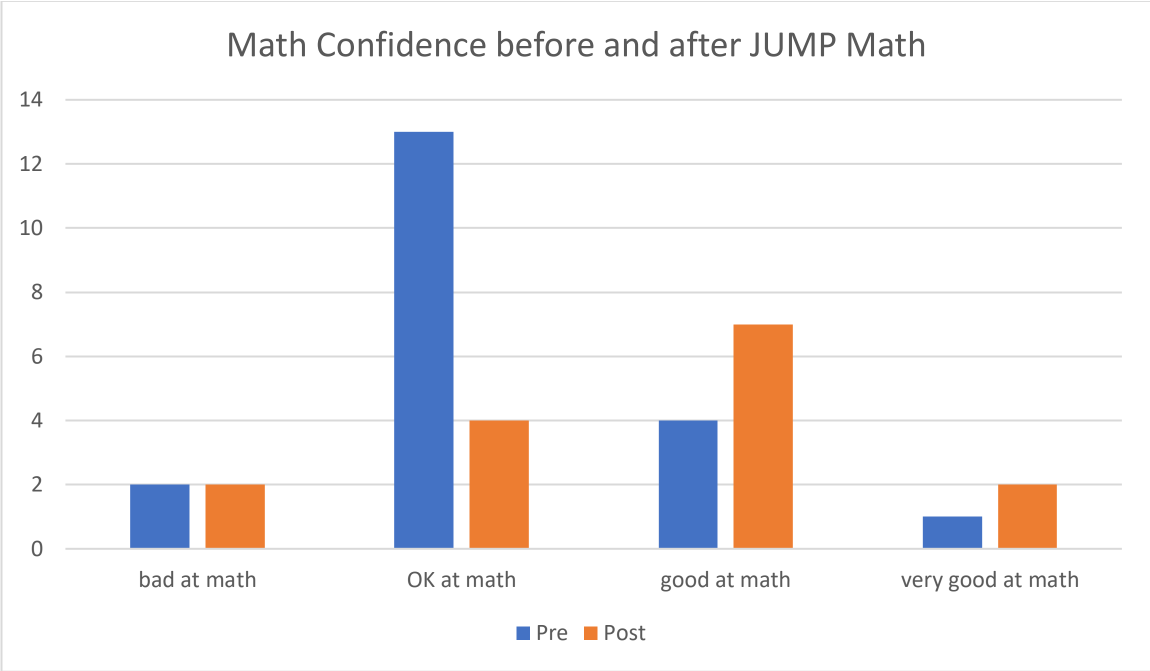


Figure 5

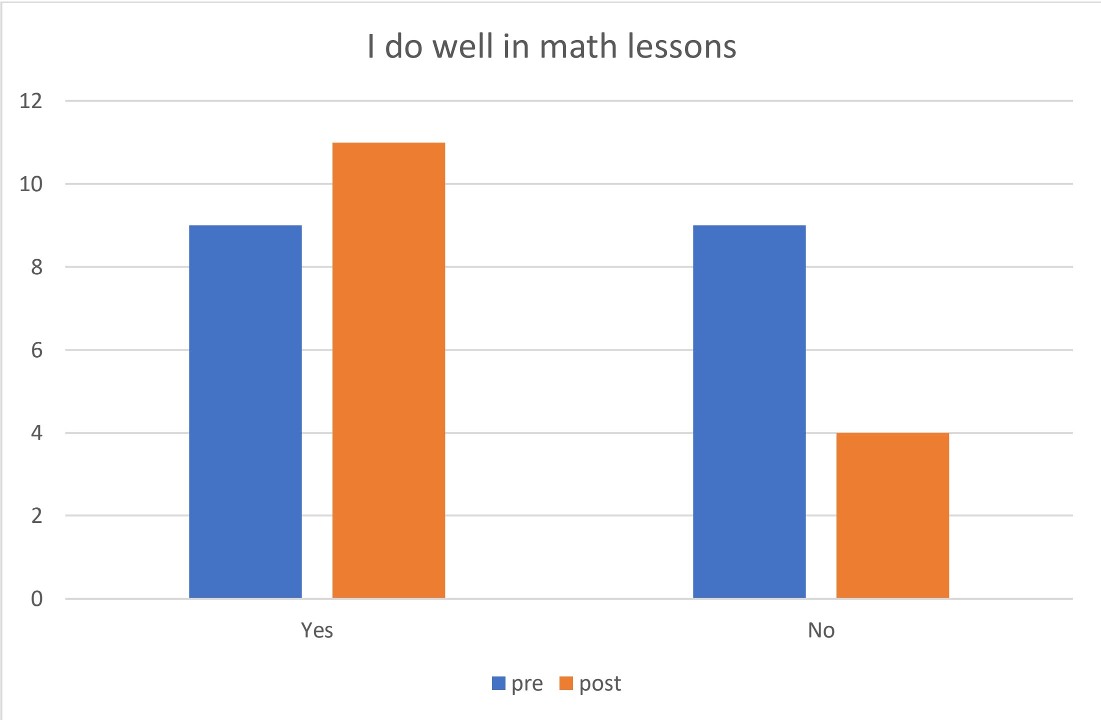
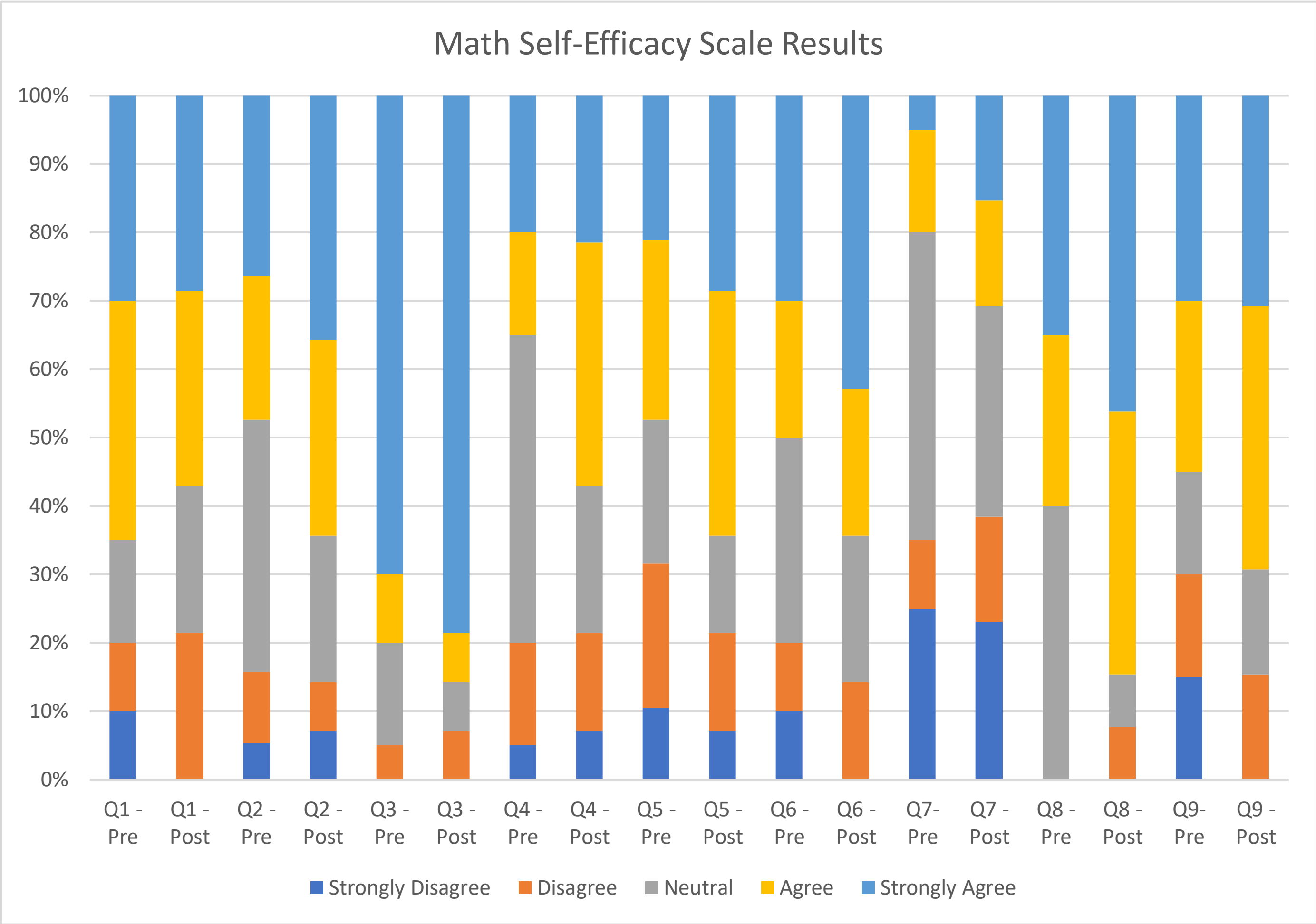


Figure 6


Math Self-Efficacy Scale Results
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Q1 - Pre
Q1 - Post
Q2 - Pre
Q2 - Post
Q3 - Pre
Q3 - Post
Q4 - Pre
Q4 - Post
Q5 - Pre
Q5 - Post
Q6 - Pre
Q6 - Post
Q7- Pre
Q7 - Post
Q8 - Pre
Q8 - Post
Q9- Pre
Q9 - Post
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree