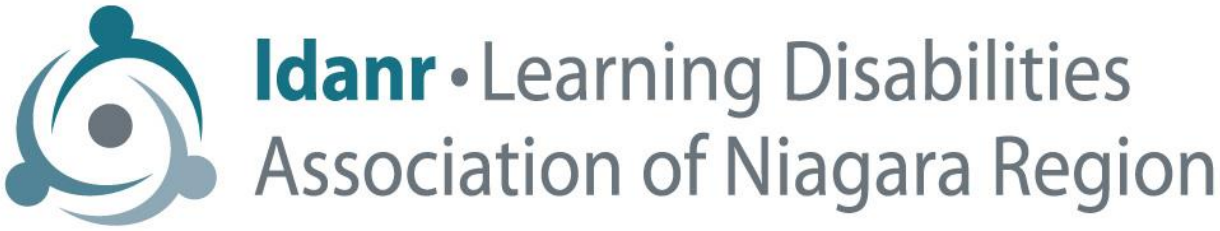
Evaluation of Online Teaching Methods for Students with Learning Disabilities: An Analysis of the JUMP Math Tutoring Program



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Introduction

JUMP Math is a non-profit Canadian organization that develops research-based teaching resources which allow educators to deliver curriculum-aligned math lessons (Garforth, 2013). Through the support of the Ontario Trillium Foundation (OTF) and permission from the JUMP Math organization, the Learning Disabilities Association of Niagara Region (LDANR) is able to provide online one-on-one numeracy tutoring to students who have a diagnosed or suspected learning disability. Students in grades one through eight who demonstrate mathematic capabilities one year or more behind grade level are accepted into the program (Randhawa, 2021). These individualized sessions incorporate repeated practice and confidence boosting initiatives to develop safe and effective environments for students, allowing them to reach their potential in mathematical learning (Preciado-Babb, et al., 2018). Additionally, by delivering one-on-one sessions, the lessons can be tailored to the students' needs which better reduces mathematical anxiety and increases competency (Solomon, et al., 2019). Overall, this program aspires to nurture students' confidence in their mathematical capabilities (Bryce, 2016).

As mentioned, many students in the JUMP program have either a diagnosed or suspected learning disability most often being dyscalculia. Dyscalculia is a specific impairment affecting the mathematical ability of children which makes it difficult to comprehend numerical computations. This difficulty is not a result of a low IQ, sensory difficulties, or a lack of education (Morsanyi et al., 2018). Additionally, it is common that students with dyscalculia feel negative emotions towards mathematics such as anxiety and tension which can interfere with their mathematical potential (Kucian et al., 2018). As there are many theories behind the cause of dyscalculia, it has been categorized as a heterogenous disorder and can lead to difficulty in

retaining mathematical facts on a long-term basis (Craig, 2019). To support students with these difficulties, the LDANR modified the JUMP Math curriculum to create their JUMP program.

The LDANR started the JUMP Math program in 2019, initially offering it as a one-on-one, in person program. Given the pandemic that began at the end of 2019, the LDANR shifted the program online using Microsoft Teams in order to serve its participants. However, the LDANR was unsure how successful the program would be in an online environment as there is a lack of clarity about effective learning strategies within online environments (Straub & Vasquez, 2015), especially for students with special education needs. More specifically, researchers have expressed concerns for students with learning disabilities encountering barriers in mathematical understanding as online learning continues (Deshler, et al., 2012). Studies have demonstrated that reduced motivation and lack of concentration can act as barriers for students' engagement in online environments leading to mathematical anxiety (Makarova, 2021). This can result in further disparities in mathematical learning for students with learning disabilities as they are already at an increased risk of feeling negative emotions towards mathematics (Kucian et al., 2018). However, it has been demonstrated in studies that synchronous learning with live sessions can contribute to increased engagement, improved comprehension, and performance on assessments (Dahlstrom-Hakki, Alstad, & Banerjee, 2020).

In the past, The LDANR has completed a quantitative analysis of the JUMP Math Program's effectiveness in a face-to-face environment, but no quantitative analysis has been done to date of the JUMP Math Program in an online environment. The quantitative analysis for the in-person sessions compared the pre-assessment and post-assessment scores, which were based on the different grade levels of the students: A (grades 1-2), B (grades 3-4). C (grades 5-6), D (grades 7-8) (Craig, 2019). Through analyzing the results of the statistical test and the

descriptive statistics, it was evident that there was an improvement in the children's mathematical capabilities as the post-assessment scores were significantly higher than the pre-assessment scores (Craig, 2019). Although a quantitative analysis was completed by the LDANR demonstrating the positive impact of the in-person program, the aim of the present report is to quantitatively evaluate the effectiveness of the JUMP Math Program in an online environment and compare the results to the findings of the previous quantitative report.

Methods

Participants

There were 20 students who participated in the JUMP program over the course of the Winter 2021 session. The student participants came from various parts of the Niagara Region and are presumed to be of varying socio-economic backgrounds, although no socio-economic data was explicitly collected. The students were between the ages of 8 and 13, with the average age being 9. There were 13 males and 9 females in the sample.

Materials

Pre & Post-Assessment

The pre- and post-assessment utilized by the LDANR were identical both in structure, content, and administration. The assessment tool was separated into four different areas which included: patterning and algebra; operations; application; and number sense. Each question from these four sub-assessments was connected to a specific JUMP Math lesson (described below).

The sub-assessments were comprised of eight levels from Level A to Level H. These levels coincided with Grades 1 through 8 but were labelled with letters so as not to discourage students working at a level lower than their current school grade. Each level in the operations, patterning and algebra, and number sense assessment were worth 10 points, and each level in the

application sub-assessment was worth 5 points. This means that a perfect score on the whole assessment was 35 points. The tutors were instructed by the program coordinator to start at a specific assessment level based on information that was collected on the LDANR's JUMP Math program application.

JUMP Math Lesson Materials

JUMP Math is a registered non-profit who created a math curriculum designed to teach students struggling with numeracy. The proprietary lesson materials are licensed for use by JUMP Math and therefore, cannot be elaborated on extensively in this section. The lesson materials, which include lesson plans and digital lesson slides, align with the strands of the Ontario Mathematics curriculum which include: number sense; measurement; geometry; data analysis; and algebra. In general, the materials focus on enhancing mathematical capability by breaking down larger concepts into smaller concepts, using clear language and visuals, and building in repetition and reflection to each lesson.

Procedure

As a result of the COVID-19 pandemic, the one-on-one numeracy tutoring sessions were completed through Microsoft Teams. The children met with their tutors for one-hour sessions two times per week for a total of eight weeks. During the Winter 2021 session, which ran from the beginning of February until the beginning of April, the LDANR offered 20 program spots with the goal of increasing students' mathematical capability and confidence through repeated practice, explicit instruction, and goal setting techniques.

The first three sessions were dedicated to completing a pre-assessment which helped enhance the tutor's understanding of their student's level of mathematical competency. The

results from this pre-assessment were then used by the tutor to plan which JUMP lessons to deliver, and which activities to incorporate for the duration of the program.

Once the pre-assessment was completed, the lesson structure for The LDANR's JUMP Math Program was the same for the remaining sessions outside of the post-assessment sessions. The sessions began by completing some form of mental math activity. For approximately 10 minutes, the tutor and their child completed a mental math activity such as number talks, subitizing, or addition and subtraction, for example. After this part of the lesson, the tutor delivered a targeted JUMP Math lesson to their student based on the results of the pre-assessment. The lessons were from the four areas of instruction outlined above. After the targeted JUMP Math lesson, the tutor chose an activity to play with their student for approximately 20 minutes which reinforced the mathematical concepts taught in the targeted JUMP lessons.

The last three sessions of the program were dedicated to completing the post-assessment which helped demonstrate students' improvement in mathematical competency. The post-assessment administered was identical to the pre-assessment.

Data Analysis

After the completion of the pre- and post-assessments as outlined above, a quantitative analysis of The LDANR's online JUMP Math program was conducted. Out of the 20 participants, 19 participants' data were analyzed. The one participant's data were removed due to missing data points in the post-assessment. After the data were removed, descriptive statistics were computed for both the pre-assessment and post-assessment in their entirety. Then descriptive statistics were computed for each subsection of both the pre-assessment and post-

assessment. After descriptive statistics were collected, an analysis of the pre- and post-assessment scores was completed.

To analyze the pre- and post-assessment scores, a Wilcoxon Signed Rank Test was completed. This non-parametric statistical test was conducted because of the paired nature of the data. Specifically, the Wilcoxon Signed Rank Test, which is designed to evaluate change in median scores for sets of data (i.e. pre and post), does not assume normality in the data and is more robust against small sample sizes. This statistical test will compare the pre-assessment and post-assessment scores of each child to determine if there was an improvement in math skills.

Results

The pre-assessment and post-assessment tools were analyzed to evaluate the effectiveness of the online JUMP Math program. Specifically, the research team wanted to examine if the JUMP program enhanced students' mathematical capabilities. The mean, range, and standard deviation values for each subsection of the pre-assessment and post-assessment tool were compared. The four sections of the assessment tool included: application; operation; number sense; and patterning and algebra. The results, which indicate an improvement in assessment scores, observed from the pre-assessment to the post-assessment tool are summarized in Table 1 below.

Table 1

Comparison of Pre-Assessment Tool with Post-Assessment Tool

Assessment	Range	Min.	Max.	Mean	Std. Deviation
Application (Pre)	5.00	0.00	5.00	2.68	1.2158
Application (Post)	2.50	2.50	5.00	4.04	1.7502
Operations (Pre)	9.00	1.00	10.00	6.53	2.894
Operations (Post)	6.50	3.50	10.00	8.47	1.7518
Number Sense (Pre)	10.00	0.00	10.00	6.50	2.81664
Number Sense (Post)	3.00	7.00	10.00	9.00	1.2360
Patterning/Algebra (Pre)	9.00	1.00	10.00	7.40	2.39985
Patterning/Algebra (Post)	4.25	5.75	10.00	9.30	1.13828

Overall, students improved on each area of the assessment as noted by the increased mean score on each of the post-assessments compared to the pre-assessments. The pre-assessment mean score for all four sub-assessments combined was approximately 23 points, with scores ranging from 12 to a maximum score of 32. Overall, there was an improvement in mathematical capabilities was evident as the total post-assessment mean score was approximately 31 points with the range from 19 to 35. This mean score increase of 8 points equates to an average improvement of 35.34% in the total scores from the pre-assessment to the post-assessment (see Table 1 in Appendix).

The pre-assessment and post-assessment tool were then evaluated using the statistical software SPSS Statistics. A Wilcoxon Signed Rank Test showed that the Online JUMP Math program significantly increased the median of the total post-assessment scores compared with

the total pre-assessment scores (Z=-3.825, p <0.001). Additionally, a Wilcoxon Signed Rank Test showed that the JUMP Math program significantly increased the median of all areas of the assessment, specifically application (Z=-3.475, p <0.001), operation (Z=-2.967, p <0.003), number sense (Z=-3.471, p <0.001) and patterning & algebra (Z=-2.582, p <0.010). This means that the post-assessment scores of all four sub-assessments were significantly higher than the pre-assessment scores (see Table 3 in the Appendix for the statistical summary).

Discussion

As a result of the COVID-19 pandemic, the LDANR's JUMP Math program was offered online through Microsoft Teams. This report illustrates the first quantitative analysis on the JUMP Math Program in an online environment and aims to compare the student outcomes to those observed during in-person program sessions. Therefore, the results and findings of this report will be generally compared with the findings from the quantitative analysis of the in-person LDANR JUMP Math Program (Craig, 2019).

Through the evaluation of the pre-assessment and post-assessment scores, the impact of the JUMP Math online program on students' mathematical abilities became clear. Specifically, there was an noticeable improvement in each section of the assessment when evaluating the mean scores of each student. When comparing the medians in the statistical test, it was also shown that the median scores of the pre-assessment were lower compared to the post-assessment, indicating that the scores in the pre-assessment were significantly lower than the post-assessment. These findings indicate that as a result of the online JUMP Math program, students' mathematical abilities increased.

In comparison to the quantitative analysis performed on the in-person JUMP Math program (Craig, 2019), the findings in the present report demonstrate comparable improvements

in students' math performance. In relation to the in-person JUMP Math program analysis, which demonstrated an improvement in median scores for all students in grades three through eight, the present findings actually demonstrate that for students in all levels there was an improvement. It should be noted that it is difficult to directly compare the in-person analyses (Craig, 2019) to the present online findings as the program that Craig (2019) analyzed also used a slightly different assessment and program format. However, when looking at the findings in both reports holistically, it is evident that they both improve mathematical capacity and in fact, the online program appears to be more efficacious as it significantly improved post-assessment scores across all participants instead of just participants in grades three through eight.

The results demonstrate the immense impact of the online JUMP Math program on students' mathematical capabilities. Despite the transition to an online environment, this program has demonstrated comparable outcomes to the in-person program and illustrated a positive influence on participating children. The transition to an online environment can create barriers to engagement (Deshler, et al., 2012) and communication methods, and little is known to date about the most effective strategies for online teaching (Straub & Vasquez, 2015), especially for students with learning disabilities. However the improvement demonstrated in this report demonstrates that using synchronous, live sessions online works to improve comprehension and performance in mathematics. Ultimately, despite difficulties with online learning and a preference for in person learning noted within the LDANR, the program at the very least, was able to help students expand their knowledge in mathematics. In running this program online, the LDANR was able to continue supporting children, especially with their transition to online schooling, and actually made the program more accessible to many remote communities in the

region. In conclusion, the online JUMP Math program is efficacious in the development of mathematical knowledge, skills, and abilities of the participating children.

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Appendix A

Table 1: *Descriptive Statistics of Pre-assessment and Post-Assessment Scores*

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
App_Pre	19	5.0	.0	5.0	2.684	1.2158
App_Post	19	2.5	2.5	5.0	4.037	.7096
Opr_Pre	19	9	1	10	6.53	2.894
Opr_Post	19	6.5	3.5	10.0	8.474	1.7518
NS_Pre	19	10.00	.00	10.00	6.5026	2.81664
NS_Post	19	3.0	7.0	10.0	9.000	1.2360
PA_Pre	19	9.00	1.00	10.00	7.4032	2.39985
PA_Post	19	4.25	5.75	10.00	9.3026	1.13828
Total_Pre	19	20.00	12.00	32.00	23.1163	6.06303
Total_Post	19	15.75	19.25	35.00	30.8132	3.81473
Valid N (listwise)	19					

Table 2: *Wilcoxon Signed Ranks Test Output*

		N	Mean Rank	Sum of Ranks
App_Post - App_Pre	Negative Ranks	2[a]	1.75	3.50
	Positive Ranks	15[b]	9.97	149.50
	Ties	2[c]		
	Total	19		
Opr_Post - Opr_Pre	Negative Ranks	2[d]	5.50	11.00
	Positive Ranks	14[e]	8.93	125.00
	Ties	3[f]		
	Total	19		
NS_Post - NS_Pre	Negative Ranks	1[g]	1.00	1.00
	Positive Ranks	15[h]	9.00	135.00
	Ties	3[i]		
	Total	19		
PA_Post - PA_Pre	Negative Ranks	2[j]	5.75	11.50
	Positive Ranks	12[k]	7.79	93.50
	Ties	5[l]		
	Total	19		

Total_Post - Total_Pre	Negative Ranks	0[m]	.00	.00
	Positive Ranks	19[n]	10.00	190.00
	Ties	0[o]		
	Total	19		

a. App_Post < App_Pre

b. App_Post > App_Pre

c. App_Post = App_Pre

d. Opr_Post < Opr_Pre

e. Opr_Post > Opr_Pre

f. Opr_Post = Opr_Pre

g. NS_Post < NS_Pre

h. NS_Post > NS_Pre

i. NS_Post = NS_Pre

j. PA_Post < PA_Pre

k. PA_Post > PA_Pre

l. PA_Post = PA_Pre

m. Total_Post < Total_Pre

n. Total_Post > Total_Pre

o. Total_Post = Total_Pre

Table 3: *Wilcoxon Signed Ranks Test Statistic*

	App_Post - App_Pre	Opr_Post - Opr_Pre	NS_Post - NS_Pre	PA_Post - PA_Pre	Total_Post - Total_Pre
Z	-3.475[b]	-2.967[b]	-3.471[b]	-2.582[b]	-3.825[b]
Asymp. Sig. (2-tailed)	<.001	.003	<.001	.010	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.