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Bridging the Gap for Low-Performing Students in Math Fact Fluency and Automaticity in Post-pandemic Education

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Abstract. The COVID-19 pandemic has exacerbated mathematical proficiency gaps among students, particularly in math fact fluency and automaticity. This study addresses these gaps by investigating the effect of the Learning Support Intervention (LSI) on low-performing grade four students. Thirty-eight students were selected based on their math performance during the previous term and their math teachers' recommendation and participated in the LSI, which was evaluated using a mixed method design combining quantitative pretest-posttest assessments and qualitative insights from focus group discussions. The results showed a significant improvement in math fact fluency and automaticity, with mean scores increasing from 49.12 to 82.61, corresponding to a shift from "Did Not Meet Expectations" to "Very Satisfactory." Key findings highlighted the LSI's effectiveness in promoting engaging learning experiences and targeted interventions without disrupting regular classes. However, challenges included venue inconsistencies and scheduling conflicts. The study underscores the importance of tailored interventions to address pandemic-induced learning gaps, emphasizing the need for adaptable and effective educational strategies to enhance mathematical proficiency.

Keywords: Automaticity; Learning support intervention for math; Math fact fluency.

1.0 Introduction

The COVID-19 pandemic has profoundly impacted educational institutions worldwide, shifting from traditional classroom settings to online and remote learning modalities (UNESCO, 2020; Syauqi et al., 2020; Crawford et al., 2020; Hodges et al., 2020). This transition has led to significant challenges in mathematics education, particularly for low-achieving students who have experienced a learning backlog due to non-face-to-face instructions (Schult, Mahler, & Lindner, 2021). Despite efforts to address these challenges worldwide through various strategies like online tutoring and digital resources (John & Mills, 2021; Knopik & Oszwa, 2021; Nabayra, 2022), poor computational fluency remains a critical issue. Math fact fluency, the ability to rapidly and accurately perform basic operations (Musti-Rao et al., 2015; Nelson et al., 2016), is essential for advancing mathematics. Students with strong fluency can recall math facts quickly, allowing them to focus on more complex tasks (Frawley, 2012; Thompson, 2017). Research highlights the effectiveness of practice with modeling in improving math skills (Codding, Burns, & Lukito, 2011).

Fourth-grade students have faced unique educational challenges, completing their early years online and experiencing blended instruction. This has notably affected their math fact fluency and automaticity, areas identified by teachers as needing improvement. While drill-based methods are effective, educators struggle to balance instructional time between repetitive practice, problem-solving, and achieving curriculum competencies

(Schult, Mahler, & Lindner, 2021). Targeted interventions for low-performing students are a continuing quest among math teachers as they emphasize the need for effective strategies in closing the mathematical learning gaps that the COVID-19 pandemic has exacerbated.

Learning Support Intervention in Math

Educators have integrated and evaluated different forms of math support for students who may have difficulty learning Math competencies or those with learning gaps. These are structured programs based on frameworks and their purpose, which are integrated into the educational system's curriculum. For instance, Björn et al. (2018) compared RTI frameworks in Finland and the U.S., noting that while both aim to prevent learning difficulties, Finland's framework integrates support services into the educational system. In contrast, the U.S. RTI primarily identifies learning difficulties. Another is the study of Parker et al. (2019), which found that a math intervention program delivered with community support had a significant positive effect on math achievement for at-risk students in Grades 4-8, with increased effectiveness under optimal conditions, highlighting the benefits of school-community partnerships in improving math outcomes. Gersten et al. (2008) also identified effective instructional strategies for students with learning disabilities in mathematics, such as explicit instruction, heuristics, visual representations, and real-world applications. They emphasized the importance of ongoing formative assessment and feedback for teachers.

In the context of the research locale, a private basic education institution in Cebu, Philippines, the after-school Learning Support Intervention or LSI consisted of a structured set of drill-based sessions designed to provide academic support and assistance to a homogeneous group of low-performing students. This intervention aimed to help them develop their math fact fluency and automaticity. Each session began with a 5-minute introduction covering fundamental operational concepts and various strategies applicable to these operations. Then, students engaged in various math fact activities, incorporating games and activities, interactive discussions, and primarily pen-and-paper timed drills. In this learning support intervention, teachers focused on targeted assistance and a more personalized approach than the heterogeneous groups in regular classes. Students were exposed to mental computation strategies such as "making tens or bridging to ten," "near doubles," "breaking down," and "using friendly numbers." However, this structured learning support intervention had not been formally evaluated, so teachers were not formally informed about whether it significantly contributed to the student's academic improvement.

This study aimed to assess the effect of the Learning Support Intervention (LSI) on low-performing grade 4 students' math fact fluency and automaticity. The objectives are to 1) profile students' performance levels in math fact fluency and automaticity; 2) evaluate the effectiveness of the LSI through pretest and posttest comparisons; and 3) identify the highlights and lowlights of the intervention. The significance of this study lies in its contribution to addressing pandemic-induced learning gaps and enhancing educational strategies for math proficiency.

2.0 Methodology

2.1 Research Design

This research employed a mixed-method design with two phases: first, the collection and analysis of quantitative data followed by collection, and second, the collection and analysis of qualitative data to support and explain the quantitative results. Quantitative data were collected using a one-group pretest-posttest pre-experimental design to describe and compare students' performance before and after exposure to the Learning Support Intervention. Then, qualitative data were gathered from the same group of participants through a Focus Group Discussion to support the quantitative results. Descriptive and inferential statistics were used to analyze the quantitative data using the statistical software Jamovi version 2022, while content analysis was used to analyze the qualitative data.

2.2 Research Participants

A total of 38 identified low-performing grade four students whose grades in the first term of SY 2023–2024 fell into the Needs Improvement level (below 75) were invited to participate in the after-class Learning Support Intervention. The same group of student participants later joined an FGD to deepen their understanding of the intervention's highlights and lowlights from the students' perspective.

2.3 Research Instrument

Two instruments were used for this research: a researcher-made pretest and posttest assessing math fact fluency and automaticity and a semi-structured interview questionnaire for the FGDs. Both instruments underwent validation by three experts: two in mathematics and one in educational management. Criteria used in validation included assessing alignment, item distribution, cognitive processes, and the representativeness of items to the measured competencies.

2.4 Data Gathering Procedure

Identifying the Low-performing Students in Math 4

The student-participants were first identified as low-performing in math based on two criteria: their actual Term 1 grade, which fell into the Needs Improvement category (below 75), and the math teachers' recommendation based on the student's math fact fluency and automaticity skills. They were then enrolled in the after-school Learning Support Intervention with their parents' consent.

Implementing After-school Learning Support Intervention

The identified low-performing student participants were asked to attend the after-school Learning Support Intervention for Math. They underwent a structured set of 36 drill-based sessions, held three to four times a week, each lasting 40 minutes, throughout Term 2 of the school year 2023-2024. During these sessions, they completed paper-and-pen timed drills. They were exposed to mental computation strategies such as "making tens or bridging to tens," "partitioning," "near doubles," "breaking down," and "using friendly numbers" for each operation.

Assessment and Monitoring

Before implementing the learning support intervention, students were pretested to establish their baseline math fact fluency and automaticity performance. Their progress was assessed and monitored during the sessions through drill scores, allowing teachers to adjust the intervention as needed, such as the need to adjust the time limit and the difficulty level if the scores were too low or too high. Finally, students were post-tested after the last session for Term 2 to determine if their performance had improved after exposure to the intervention. Focus group discussions were then conducted to deepen understanding of the assessment results and evaluate the implementation of the Learning Support Intervention for administrative decision-making.

2.5 Data Analysis Procedure

The statistical software Jamovi 2.3 was used to tabulate and analyze quantitative data. Descriptive statistics were employed to summarize student performance. At the same time, a paired t-test was conducted to determine whether the difference in students' computational skill levels before and after the intervention was statistically significant. For qualitative data from the FGDs, systematic coding and thematic analysis were conducted to identify recurring themes and insights.

2.6 Ethical Considerations

Formal research clearance was obtained from the grade school principal's office and the Institutional Research Council through a transmittal letter before the study's commencement. As participants were minors, informed consent was secured from parents/guardians, detailing the study's objectives, data requirements, and procedures. Participation in the study was voluntary and invitation-only. Students received an orientation about the study's processes and signed an Assent Form to indicate their willingness to participate. Additionally, students were informed of their right to withdraw from the study without any sanctions in their math subject. To ensure confidentiality and minimize bias, a coded list linking sections to anonymized IDs, questionnaires and answer sheets were stored securely, test questionnaires excluded identifiable participant information, and participant identities were concealed in all written and verbal reports. All data were handled confidentially and stored securely for six months before being shredded for disposal.

3.0 Results and Discussion

3.1 Performance Before and After Exposure to Learning Support Intervention

The 38 low-performing students who took the pretest on math fact fluency and automaticity achieved a mean score of 49.121, corresponding to a grade of 72, falling under the Did Not Meet Expectations level. However, after being exposed to the learning intervention program for the entire term, consisting of 36 sessions, the group

achieved a mean score of 82.606, corresponding to a grade of 88, falling under the Very Satisfactory level, as shown in Table 1.

Table 1. *Performance before and after exposure to learning support intervention*

Test Period	Mean (SD)	Transmuted Grade	Description
Before the exposure	49.12 (18.00)	72	Did Not Meet Expectations
After the exposure	82.60 (16.52)	88	Very Satisfactory

The data indicate a noticeable improvement in the average performance level of the students, shifting from Did Not Meet Expectations to Very Satisfactory. The transmuted grade 88 suggests that most students achieved a Very Satisfactory performance level after the intervention. A Very Satisfactory level of performance means that the expected acceptable level of performance in math fact fluency and automaticity was met after exposure to the intervention. It was observed that most students could complete at least 85% to 100% of the test within the allotted time. These findings align with Codding, Burns, and Lukito's (2011) meta-analysis, which identified strategies like timed practice, explicit instruction, and corrective feedback as potentially effective components in improving math fact fluency and automaticity. They also highlighted the critical role of working memory in quickly and accurately retrieving math facts. Luciani's (2018) thesis on digital games to improve math fluency supports these findings. She found that while some studies show mixed results regarding the impact of online math games on math performance and attitude, others suggest that computer-aided instruction can positively affect math fact fluency when used with strong core instruction. Ultimately, these games offer opportunities to build basic math fluency through interactive activities, potentially enhancing cognitive learning and promoting a more positive attitude toward mathematics (Luciani, 2018). These findings are relevant to the current study since the LSI also involves digital games during the intervention.

Both Morano et al. (2020) and Baker et al. (2018) emphasized the importance of math fact fluency for overall success in mathematics. Therefore, schools must provide learning support interventions to students in math during the post-pandemic period to help them catch up, especially low-performing ones. These skills matter because they free up the brain's working memory to perform more complex mathematical tasks, such as solving multistep problems.

3.2 Comparative Analysis of the Pretest and Posttest Scores

A comparative analysis to identify whether or not there is a significant difference in students' math fact fluency and automaticity skills before and after exposure to Learning Support Intervention. As shown in Table 2, the paired difference between the pretest and posttest scores of Grade 4 students is calculated as 33.485 (SD = 13.175). The t-value is 13.288, with a P-value of less than 0.05, indicating that the difference between the pretest and posttest scores is highly significant. Based on the mean values, the results suggest that the post-test scores are significantly higher than the pretest results. In other words, students' performance has significantly improved after exposure to the learning support intervention. This implies that, statistically, the learning support intervention has helped students improve their math fact fluency and math fact automaticity skills. This improvement can be attributed to the students' regular exposure to fact fluency drills and games.

Table 2. *The difference in students' performance before and after intervention*

Dependent Variable	Pretest Mean (SD)	Posttest Mean (SD)	Paired Difference Mean (SD)	t	p
Students' Performance	49.12 (18.00)	82.60 (16.52)	33.48 (13.17)	14.60	<0.001

This finding is consistent with the results of Lozano (2019) and Leseca et al. (2021), who found in their studies that timed drills were effective in improving students' speed and accuracy when solving math problems. They further recommended using timed practice drill interventions in teaching mathematics across all years and grade levels to enhance academic achievement.

3.3 Highlights of the Learning Support Intervention

The highlights represent the best features and areas to celebrate the learning support intervention as perceived and shared by students and teachers during the research and in the FGD, as well as the outstanding parts and periods observed by teachers. Four themes emerged as highlights.

Theme 1: Promotes Fun Learning Experiences and Challenges Students to Acquire Strategies

The first highlight shows how learning support intervention in mathematics creates engaging and enjoyable learning experiences while challenging students to develop math fact fluency and automaticity. By making learning fun, the intervention motivated students to participate and acquire the skills actively. One key feature of the learning support intervention is the flow of activities, ensuring a well-organized and progressive structure to the sessions. Integrating drill games and technology, including using tablets during sessions, led to fun and interactive learning experiences among students. Students enjoyed drill games, particularly mentioning number card games and competitive elements like drill tournaments.

One student mentioned: "*I like the card games and the timed drills where we compete, and you have to do it fast – it is fun.*" Another student shared: "*My favorite part is the competition using the iPad. You get to use the iPads – that is awesome – and it is fun to compete against each other.*"

Many students agreed with these statements, suggesting that the competitive aspect adds an engaging and stimulating element to the learning process, making it more enjoyable for learners. Moreover, when asked if they would like to be invited to the learning support intervention again next year, almost all students answered "Yes." This affirms that students genuinely enjoy the LSI sessions. These responses align with a teacher's comment that LSI students proudly and enthusiastically share the game drills they played during their learning support sessions with their classmates. This finding is consistent with the study by Sprague (2023) on using computer-based games to develop math fact fluency in the classroom. Additionally, Hui et al. (2023) found in their study on game-based learning that when lessons or activities involving passive repetition are presented through games, the entertainment factor motivates students to stay committed to the task, potentially making the learning experience more effective and enjoyable.

Theme 2: Provides Targeted Intervention to Selected Students Without Jeopardizing Math Periods

The second highlight emphasizes that the learning support intervention is designed to provide targeted assistance to specific students who need it without disrupting regular math classes. By offering additional support outside of regular instructional time, the intervention ensures that students receive contextualized help while maintaining the integrity of the standard math curriculum for all students.

One student mentioned: "*I learned something new like 'part + part = whole,' which is addition. I didn't know that, and the bar model.*" Another student mentioned: "*I learned different ways to solve quickly and easily.*" A student added: "*I need to strategize to win. Like when adding 7 + 9, I make 9 a 10 and get 1 from 7, so I'm left with 6. And then I can add fast.*"

Similar statements were common among other students. Some students acknowledged that long, timed drills posed a challenge, implying that this led them to strategize to finish the exercises, which may be a factor in the learning experience. The phrases "solve fast and easily" were repeated several times in students' responses. This is consistent with teachers' responses indicating that the learning support intervention and selection process must continue because it gives them opportunities to reteach basic concepts to students who need them without worrying that their class periods are jeopardized, as the learning support intervention occurs outside regular math periods. Teachers recognize the importance of math drills and acknowledge their positive impact but note that integrating them into regular math classes has taken up much of their instructional time. Teachers also mentioned that students attending the learning support intervention are more confident and display a more positive disposition in their regular math classes.

As mentioned by Wing and Evans (2027), automaticity in basic math facts serves as the foundation for advancements in mathematics. This gives students more opportunities to integrate these skills into more complex tasks and allows more time to practice more complex math skills (Thompson, 2017), thus giving them more confidence and showing better disposition in class. Peteros et al. (2019) found a significant relationship between math achievement and students' attitudes.

Theme 3: Enhances Practical Math Application Using Learned Strategies

The third highlight emphasizes how the learning support intervention not only teach theoretical concepts but also enhance students' ability to apply learned strategies in practical, real-world contexts. By focusing on practical

applications, these interventions help students connect mathematical concepts to everyday problems, fostering a deeper understanding and appreciation of mathematics as a tool for solving real-world challenges. Students, having learned different strategies, utilize them not only to achieve success in competitive games but also to enhance their efficiency in solving fact problems during long written drills.

A student said: "*Before, I could barely finish long drills. However, now I know techniques to finish them now.*" Another student added: "*Yes. Moreover, I like the 'making 10' strategy. It helps me answer fast.*"

The flow of activities in the learning support intervention is one of the key areas observed by teachers in this study. The five-minute introduction of different strategies before proceeding to various drills helps students utilize the concept of number sense and apply these strategies to answer the drills. This approach contrasts with blind memorization in timed drills of basic math facts, a concern that Boaler (2025) identified in her study.

Theme 4: Serves as a Free Study Time for Students

The fourth highlight emphasized how the learning support intervention can be structured to provide students with free study time, allowing them to work individually or in groups to reinforce their understanding of mathematical concepts. This after-school intervention supports students in developing independent study skills and enhances their ability to apply learned strategies in practical contexts.

A student said it is free study time for him by saying: "*I do not have a tutor. I study on my own. I mean, I do not know how to study. I think I do not study. So yeah, this is a free study time.*" This response sparked positive reactions within the group, with some students indicating that they resonated with this experience. Another student added: "*I always go home late because my driver picks me up late. So I play around the campus. Moreover, I try to study, but I stare at things. So now, I do not have to study because I already study here.*" When the group was asked how many study independently, most students raised their hands. One student jokingly said: "*I just pretend to study, okay.*"

Such accounts emphasized how students develop their study habits and positive disposition towards math as they constantly attend the support intervention. In their study examining the relationship between study habits and student academic performance, Rabia et al. (2017) found that good study habits positively correlate with better academic outcomes. Capuno et al. (2019) also revealed a negligible positive correlation between positive attitudes toward mathematics and their performance in mathematics.

These highlights showcased the benefits of the learning support intervention offered. It has been shown to enhance the learning experience by making it engaging and challenging while providing targeted support that complements regular instruction without disrupting it. Additionally, they foster practical applications of mathematical concepts, helping students connect theory to real-world problems. Furthermore, these interventions offer opportunities for students to develop independent study skills, reinforcing their understanding of mathematical concepts in a supportive environment.

3.4 Lowlights of the Learning Support Intervention

The lowlights discussed the negative aspects and areas needing improvement in the learning support intervention as shared and observed by students and teachers during the focus group discussion. Three themes emerged as lowlights.

Theme 1: Venue Is Not Established

The first lowlight emphasized a challenge faced due to the lack of a dedicated and established venue for conducting sessions. This absence of a consistent and suitable space can hinder the effectiveness and organization of the intervention, potentially impacting students' overall learning experience.

A student mentioned: "*What I do not like is that we always have different classrooms every afternoon. Some classrooms are clean, some are not.*"

Teachers also viewed this as a concern. Since already established intervention and enrichment programs are scheduled in various classrooms, the learning support intervention sessions always have to find an available

classroom. Both students and teachers emphasized the need for a fixed classroom to ensure consistency and stability in the learning environment. Yahya and Nur (2023) found that a well-maintained and well-designed learning environment significantly enhances students' motivation to learn and improves their academic performance. Indeed, it is important to have a consistent and conducive classroom where students stay for the learning support intervention.

Theme 2: Lacks Differentiation

The second lowlight emphasized a challenge due to the lack of differentiation in instructional approaches. Students' experiences varied significantly, with some feeling that the lessons did not adequately challenge them. For example, one student wanted to move directly to division because they had already mastered addition, indicating a need for more advanced content. Conversely, others found the pace of activities overwhelming.

One student mentioned: "*The time for doing drills is too fast. It makes me feel stressed.*"

Teachers also noted that the topics in the budget plan need to be enhanced to balance the time spent on each topic based on its difficulty. Another teacher suggested that the support group should be divided into different levels so that when students master a certain level within a given period, they can be advanced to the next level. Differentiated instruction involves tailoring teaching to meet students' diverse needs and interests. However, according to Putra (2023), educators often misunderstand this as teacher-student relations, teacher-learning design, and teacher-learning goals. The study identifies that teachers often struggle with adapting instruction to individual students' needs, particularly in setting a learning pace, providing oral feedback, and responding proactively to diverse students. These misconceptions can hinder the effective implementation of differentiated instruction, which is crucial for enhancing student learning outcomes by catering to individual differences in learning styles and abilities.

Theme 3: Does Not Have a Protected Time

This lowlight emphasized the challenge due to the lack of a dedicated, protected time for conducting sessions. Without a guaranteed and uninterrupted time slot, the intervention often faces scheduling conflicts and disruptions, hindering its effectiveness and consistency. This absence of protected time can impact the ability to deliver the intervention as intended, potentially affecting student outcomes and the program's overall success. A few students mentioned that sometimes their schedule conflicts with remedial sessions for other subjects.

One student mentioned: "*Sometimes, I am swamped. I need to go to remedial class or dance practice for Christmas.*"

Teachers expressed similar sentiments, noting that they must juggle their schedules, especially during busy periods—late November to early December. In their study on *Supporting Time Awareness in Self-Regulated Learning*, Hsu et al. (2023) found that consistent study time was associated with better performance, and therefore, time management in self-regulated learning is essential. Although the findings were more focused on self-regulated learning rather than systematic learning support intervention sessions, it can be argued that the role of time allocation dedicated by the students and the teachers comprised the protected time needed to enhance focus and productivity.

4.0 Conclusion

Based on the findings and discussions, the Learning Support Intervention (LSI) has significantly improved math fact fluency and automaticity skills among low-performing fourth-grade students. The highlights of the intervention include the promotion of fun learning experiences, targeted intervention without disrupting regular math periods, improved computational skills, and free study time. Meanwhile, the lowlights of the intervention include venue inconsistency, the need for differentiation, and potential conflicts with the schedules of other remedial sessions. This study demonstrates that the Learning Support Intervention (LSI) significantly enhances math fact fluency and automaticity among low-performing fourth-grade students. The key highlights of the intervention include its ability to promote engaging learning experiences, provide targeted support without disrupting regular math classes, improve computational skills, and offer valuable free study time. However, the lowlights of the intervention reveal challenges such as inconsistent venues, a lack of differentiation in instructional approaches, and potential scheduling conflicts with other remedial sessions. These findings underscore the

effectiveness of a well-designed intervention in improving math skills while highlighting areas for improvement. Future studies could build on these results by exploring strategies to address the need for differentiation of learning experiences and ultimately refining the intervention to meet the diverse needs of students better.

5.0 Contributions of Authors

Author 1 (Rachel Joy M. Carriaga) – ideation, writing, supervising, and data analysis; Author 2 (Ana Mae Abapo) – writing, conducting the intervention, and administering of the pretest and posttest.

6.0 Conflict of Interest

No known conflicts of interest were encountered in this study.

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