MATH-WAVE (Mathematics Advancement Through Technology and Hands-on Web-based Activities for Vital Engagement): Enhancing Grade 4 Students' Word ProblemSolving Skills Effectively

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Abstract

One of the persistent challenges among elementary pupils is solving mathematical word problems, which are essential for developing critical thinking and application skills in mathematics. This quasiexperimental study aimed to determine the effectiveness of the MATH-WAVE (Mathematics Advancement through Technology and Hands-on Web-based Activities for Vital Engagement) intervention in enhancing the word problem-solving skills of Grade 4 students. The MATH-WAVE approach integrated interactive technology tools and contextualized web-based activities designed to engage learners and improve their comprehension of mathematical problems. The intervention was implemented with 30 Grade 4 pupils from Maniki Central Elementary School SPED Center during the 2024–2025 academic year. A researcher-designed pre-test and post-test were administered to assess the participants' problem-solving performance. A paired sample t-test revealed a statistically significant difference between pre-test and post-test scores, $t(29) = 22.60$, $p < .001$, indicating a substantial gain in problem-solving skills (Cohen's $d = 4.04$). These findings suggest that the MATH-WAVE intervention effectively enhances elementary learners' mathematical problem-solving abilities. The results support the integration of technology-assisted and hands-on learning strategies into the mathematics curriculum.

Keywords: problem-solving; MATH-WAVE; mathematics; Grade 4; interactive learning; technology-based activities; Philippines

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1. Main text

Introduction

Mathematics plays a pivotal role in shaping students' critical thinking and problem-solving capabilities. However, students often struggle with mathematical problem-solving due to ineffective teaching strategies and a lack of engaging, technology-driven approaches. Global and local studies highlight the benefits of interactive and contextualized learning experiences. This study introduces the MATH-WAVE intervention, aiming to address these challenges among Grade 4 learners in a Philippine elementary school.

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Methodology

2.1. Research Design A one-group pretest-posttest design was employed to evaluate the impact of the MATHWAVE intervention on students' mathematical problem-solving skills.

2.2. Respondents Thirty Grade 4 students from Maniki Central Elementary School SPED Center in Davao del Norte were purposively selected based on their low performance in problem-solving assessments.

2.3. Procedure The intervention spanned three weeks, comprising an Introduction Phase (Week 1), an Implementation Phase (Week 2), and an Assessment Phase (Week 3). It involved structured learning experiences using digital platforms (K5 Learning and IXL Math), real-world math applications, and interactive classroom activities.

2.4. Statistical Tools Data were analyzed using mean, standard deviation, paired sample t-test, and Cohen's d to determine performance levels, variability, significance, and effect size of the intervention.

Results and Discussion

3.1. Pre-test Results The average pre-test score was 8.90 (26.67%), classified as very low. The results indicate that students lacked basic problem-solving proficiency.

3.2. Post-test Results The average post-test score increased to 24.77 (82.57%), categorized as high. This demonstrates significant improvement following the intervention.

3.3. Statistical Significance A paired t-test revealed a significant difference between pre-test and post-test scores, $t(29) = 22.6$, $p < .001$, with a large effect size (Cohen's $d = 4.04$), confirming the intervention's effectiveness.

3.4. Thematic Insights Qualitative interviews identified five key themes: recognizing the importance of problem-solving, adopting improved strategies, increased mathematical confidence, heightened motivation, and the value of interactive learning strategies.

Conclusion The implementation of the MATH-WAVE intervention significantly enhanced the problemsolving skills of Grade 4 students. Quantitative and qualitative findings support the integration of hands-on and technology-based methods in teaching mathematics.

Recommendations

- Integrate MATH-WAVE activities regularly into the math curriculum.
- Conduct teacher training on interactive digital tools and structured strategies.
- Customize activities for diverse learner needs.
- Extend research to other grade levels and contexts.

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To address the low performance in mathematical problem-solving among Grade 4 learners, a structured intervention titled MATH-WAVE (Mathematics Advancement through Technology and Hands-on Web-based Activities for Vital Engagement) was designed and implemented. This threeweek action plan aimed to strengthen learners' engagement, critical thinking, and problem-solving abilities by combining interactive digital tools with hands-on learning experiences. Aligned with the learners' weekly Mathematics schedule, the intervention emphasized visual modeling, real-life applications, and collaboration through learner-centered tasks.

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The intervention began with the Introduction Phase in Week 1. On Day 1, a 30-item pre-test was administered to assess the learners' baseline mathematical problem-solving skills. In addition to this, the researchers utilized diagnostic tools from K5 Learning and IXL Math to identify specific weaknesses in problem-solving, particularly in areas such as numerical operations and reasoning. Students were oriented on how to use the digital platforms and were introduced to structured problem-solving strategies that would be used throughout the intervention.

The Implementation Phase, conducted over Week 2 (Days 2 to 11), focused on reinforcing problemsolving concepts through guided instruction, digital exercises, and collaborative activities. During this phase, the learners were introduced to visual problem representations, Polya's four-step process (Understand, Plan, Solve, Check), and logic-based problem-solving strategies. They practiced breaking down word problems using diagrams and engaged with adaptive digital tasks on K5 Learning and IXL Math. Real-world application problems were also incorporated to make mathematics more relevant to their daily experiences. These activities included group-based math games, problem-solving contests, and a math-themed escape room challenge designed to enhance critical thinking in a fun and competitive way.

In the Assessment Phase on Week 3 (Day 12), a 30-item post-test was administered to measure the students' progress and the overall effectiveness of the MATH-WAVE intervention. This was followed by a reflection and feedback session where students were encouraged to share their learning experiences and identify how the use of technology and hands-on activities supported their understanding of mathematical concepts. The results from the pre- and post-tests served as the basis for evaluating the impact of the intervention on student performance.

Proposed Intervention/Action Plan

Phase	Time Frame	Objective	Activities/Details
Introduction Phase	Week 1 (Day1)	Conduct baseline assessment	**Day 1:** Pre-Test
Implementation Phase	Week 2 (Day 2 – 11)	Build proficiency in problem-solving using MATH-WAVE	**Day 2:** Visual problem-solving using diagrams and models **Day 3:** Hands-on modeling using manipulatives **Day 4:** Introduce Polya's 4-step method (Understand, Plan, Solve, Check) **Day 5:** Guided practice with Polya's method using IXL Math **Day 6:** Basic numerical operations via K5 Learning **Day 7:** Math relay games for step-
			by-step problem-solving **Day 8:** Logic-based problem-solving with patterns and sequencing **Day 9:** Problem-solving contest using logic-based problems **Day 10:** Real-world applications (budgeting, measurements) **Day 11:** Math escape room and review activities

Assessment Phase	Week 3 (Day 12)	Evaluate impact and reflect	**Day 12:** Post-Test

Research Question No.1: What is the level of students' mathematical problem-solving skills before the implementation of the MATH-WAVE intervention in Grade 4 learners?

The Table 2 shows the pre-test data on the problem-solving skills of grade 4 learners. There were 30 participants for the MATH-WAVE implementation. It revealed that it has an average percentage score of 29.67% indicating very low performance by the pupils in pre-test. The highest score achieved was 18, achieved by 1 student, while the lowest score is 2, also achieve by 1 student. The most frequent score was 6 and 8, with a frequency of 4.

Table 2. *Frequency of the Pre-Test Scores*

Pre-Test Score	Frequency	Percentage
2	1	3.3%
3	1	3.3%
4	1	3.3%
5	2	6.7%
6	4	13.3%
7	3	10.0%
8	4	13.3%
9	2	6.7%
10	2	6.7%
11	3	10.0%
12	2	6.7%
13	1	3.3%
14	1	3.3%
15	1	3.3%
16	1	3.3%
18	1	3.3%
Total	30	100%
Overall Mean		8.90
Average Percentage Score (%)		**26.67%**
Description		**Very Low**

These findings suggest that before the MATH-WAVE intervention, most students struggled significantly with mathematical problem-solving. The low performance can be attributed to several factors such as limited understanding of mathematical concepts, difficulty in interpreting word problems, and lack of engaging instructional strategies. According to Borromeo Ferri (2021), difficulties in solving word problems often stem from inadequate comprehension and poor integration of mathematical reasoning. Additionally, Espinosa (2020) emphasized that many Filipino students experience mathematics anxiety due to traditional teaching methods that fail to promote active engagement and understanding. Similarly, the study by Reyes and Garcia (2022) highlighted that without contextualized and technology-supported instruction, learners often find mathematical tasks abstract and demotivating, which affects their confidence and performance.

The pre-test results confirm that the participants had limited problem-solving skills and needed structured support. This underperformance underscores the necessity of implementing innovative strategies like MATH-WAVE, which integrates technology and hands-on activities to enhance engagement and understanding. As such, the baseline data in Table 2 strongly justify the need for intervention to help students achieve better outcomes in mathematics.

Research Question No.2: What is the level of students' mathematical problem-solving skills after the implementation of the MATH-WAVE intervention in Grade 4 learners?

Table 3 presents the post-test results of the 30 Grade 4 students from Maniki Central Elementary School following the implementation of the MATH-WAVE intervention. The mean score was 24.77 out of 30, corresponding to an average percentage score of 82.57%, which is categorized as "High" based on the descriptive level. The standard deviation of 3.99 reflects moderate score variability, suggesting that while students performed at different levels, the majority scored in the upper range of the test.

The highest score of 30 was achieved by 3 students (10.0%), whereas the lowest score of 17 was attained by 1 student (3.3%). The most frequently occurring score was 28, earned by 5 students (16.7%), followed by 26 with 4 students (13.3%), and scores of 29 and 30 both attained by 3 students (10.0%) each. These frequencies demonstrate a strong clustering of scores near the top of the performance scale, reflecting the effectiveness of the intervention.

Table 3. *Frequency of the Post-Test Scores*

Post-Test Score	Frequency	Percentage
17	1	3.3%
18	1	3.3%
19	2	6.7%
20	2	6.7%
21	1	3.3%
22	3	10.0%
23	2	6.7%
24	1	3.3%
25	1	3.3%
26	4	13.3%
27	1	3.3%
28	5	16.7%
29	3	10.0%
30	3	10.0%
Total	30	100%
Standard Deviation		3.99
Average Percentage Score (%)		**82.57%**
Description		**High**

These results demonstrate a notable improvement in students' problem-solving performance compared to the pre-test, which had a much lower average score of 8.90 (29.67%), categorized as “Very Low.” The comparison between pre-test and post-test data reveals a substantial shift in performance level, with most students scoring well above the midpoint of the 30-item test, and several achieving near-perfect scores.

The considerable increase in scores suggests that the MATH-WAVE intervention was highly effective in enhancing students’ mathematical word problem-solving skills. Learners exhibited better comprehension and application of mathematical concepts, which may be attributed to the structured assistance methods, interactive digital tools, and handson activities embedded in the intervention. These strategies likely helped students understand problems more deeply, apply solution methods with greater accuracy, and approach mathematics with increased confidence.

Moreover, the results imply a strengthened ability among students to interpret problem scenarios, determine appropriate operations, and carry out solutions successfully. The consistent use of platforms like K5 Learning and IXL Math, along with real-life contextual tasks, contributed to deeper conceptual understanding and heightened student engagement.

These findings are consistent with Sorenson et al. (2023), who emphasized the positive effects of interactive software in developing math skills, and Nguyen et al. (2021), who found that digital learning tools can significantly boost engagement and learning outcomes in mathematics. The observed improvements also echo Borromeo Ferri’s (2021) assertion that structured instructional strategies and contextual understanding are critical to successful mathematical problem-solving.

In conclusion, the data from Table 3 reinforce the effectiveness of the MATH-WAVE intervention in elevating students’ mathematical proficiency. The intervention not only resulted in higher post-test scores but also appears to have transformed students’ problemsolving approaches. These outcomes support the continued integration of technologyenhanced, contextualized, and hands-on strategies in elementary mathematics education to foster deeper learning and improved academic achievement.

Research Question No.3: Is there a significant difference in the mathematical problem-solving skills of Grade 4 learners before and after the implementation of the MATH-WAVE intervention?

Table 4. *Significant Difference Between the Pre-Test and Post-Test Scores*

Type of Test	*N*	*df*	*Mean*	*Mean difference*	*SE difference*	*SD*	*tvalue*	*Pvalue*	*Cohen’s d*	*Decision α=0.05*
Pre-Test	30	29.0	8.90	15.9	0.701	3.86	22.6	<.001	4.04	Significant
Post-Test	30		24.77			3.99				

Presented in Table 4 was the result of the significant difference between the pre-test and post-test scores, $t(29) = 22.6$, $p < .001$. Since the probability value ($< .001$) is less than the level of significance ($\alpha = 0.05$), the null hypothesis is rejected. This indicates that there is a significant difference between the pre-test and post-test scores of the students after the implementation of the MATH-WAVE intervention. The result suggests that the structured use of technology-based and hands-on activities greatly enhanced the mathematical word problem-solving skills of the students. The significant increase from the mean pre-test score of 8.90 to the post-test mean of 24.77 demonstrates the effectiveness of the intervention in addressing previous learning gaps and improving comprehension and application of mathematical concepts.

In connection with the result, Stahl and Nagy (2020) emphasized that repeated exposure to learning content allows students to encounter information in a variety of contexts, helping them better understand the full range of its applications. Similar to vocabulary acquisition, when students are repeatedly exposed to mathematical problems and practice them through different tools and platforms, they begin to internalize the strategies and processes involved, leading to better retention and skill mastery.

Similarly, Nguyen and Kulikowich (2021) found that traditional, teacher-centered methods often result in low engagement and minimal conceptual understanding, particularly in mathematics. They argued that incorporating interactive technologies and learner-centered approaches can significantly boost students' interest and achievement by making abstract concepts more accessible and relevant. This supports the rationale behind MATH-WAVE, which provides engaging and meaningful experiences through technology and hands-on tasks—helping reduce learner boredom and encouraging active participation.

Moreover, Blachowicz and Fisher (2020) highlighted the importance of consistent practice in reinforcing student learning and building confidence. By engaging students with continuous and interactive mathematical tasks, MATH-WAVE enabled them to strengthen their problem-solving skills and apply them more effectively in various scenarios.

Lastly, the Depth of Processing Theory by Craik and Tulving (2021) supports this outcome by stating that the more deeply learners engage with content, the stronger their memory and understanding become. The MATH-WAVE approach encouraged students to not only practice solving problems but also understand their context and apply reasoning, leading to improved long-term retention and deeper comprehension.

In conclusion, the results of Table 4 clearly support the effectiveness of the MATHWAVE intervention. The significant difference between the pre-test and post-test scores validates that integrating technology and hands-on learning is a powerful strategy for enhancing mathematical proficiency among elementary learners.

Research Question No.4: What insights can be drawn from the implementation of the MATHWAVE intervention regarding its effectiveness in enhancing students' problem-solving abilities?

To answer this research question, in-depth interviews were conducted with the participants. Probing questions were asked to elicit their responses regarding their insights about the MATH-WAVE intervention as a strategy for enhancing their problem-solving skills in mathematics. The major themes and supporting statements are presented in Table 5. Participants shared their responses based on their experiences and observations throughout the implementation of the intervention. From the answers of the participants, five major themes emerged: (1) realization of the importance of problemsolving; (2) improved approaches to problem-solving; (3) boost in mathematical confidence; (4) increased enjoyment and motivation in math learning; and (5) integration of interactive learning strategies.

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Table 5. *Themes and Sample Statements on the Insights of Grade 4 Students in the Use of Math-Wave (Mathematics Advancement Through Technology and Hands-On Web-Based Activities for Vital Engagement) in Improving their Problem-Solving Skills.*

Emerging Themes	*Supporting Statements*
Realizing of the Importance of Problem-Solving	"At first, I thought solving problems was just about getting the answer. But in MATH-WAVE, I learned that it's actually important for learning well. Now, I understand better how to solve problems." (IDI-01) "I learned in MATH-WAVE that solving problems is important, not just for tests but also for everyday life. I've practiced thinking correctly more." (IDI-02) "I used to think math problems were just for tests. But in MATH-WAVE, I understood that they actually help with thinking skills. Now, I analyze things better." (IDI-03) "MATH-WAVE helped me understand that problem-solving is very important in math. It showed me that solving problems can be fun and not scary. I got better at thinking of different ways to solve a problem." (IDI-05) "MATH-WAVE helped me see that problem-solving is very important, not just in math but in real life too. It showed me how to think step by step and now I can solve problems better and faster." (IDI-06)
Improving Problem-Solving Approaches	Now, when I solve problems, I take my time. I make sure to understand them first and break the steps down. I don't get confused easily even if the problem is difficult." (IDI-01) "Now, I draw solutions. If I have an assignment, it's easier for me. I don't struggle to understand anymore." (IDI-02) "Now, when I answer problems, I break them down into parts. I know how to think in the right way. This also helps in other subjects." (IDI-03) "After MATH-WAVE, I started to think more carefully when solving problems. I now try to understand the problem first, then find a plan, instead of just guessing." (IDI-05) "Now when I see a word problem, I don't panic. I read it carefully, look for key words, and try to understand what it's asking. I also use the same thinking when I help my siblings or when I do homework." (IDI-06)
Boosting in Mathematical Confidence	"Before, I was afraid of math problems. But now, I know what to do. I'm not shy to answer anymore." (IDI-01) "Before, I always asked for help. Now, I try to do it on my own first. I have more confidence in myself." (IDI-02) "Before, word problems were really difficult. But now, I'm not as scared anymore. I feel more confident in solving them." (IDI-03) "MATH-WAVE helped me when I got stuck on hard problems. It taught me to not give up and try new ways. I feel more confident and prouder when I solve math problems now." (IDI-05) "It helped me understand the steps better and use pictures and clues to solve problems. I don't feel afraid of getting the wrong

answer anymore because I know how to try again and fix my mistakes." (IDI-06)

"MATH-WAVE helped me when I got stuck. It taught me not to give up and to try new ways. Now, I feel braver and proud when I solve math problems." (IDI-07)

Increasing Enjoyment and Motivation in Math Learning	"MATH-WAVE is fun because there are games, drawings, and videos. I don't get sleepy in class. I always want to do math." (IDI-01) "Before, I didn't like math. But because of MATH-WAVE, I started enjoying it. We do a lot of fun activities." (IDI-02) "I enjoy math more because of MATH-WAVE. There are computers, images, and games, which make it easier for me to understand the lesson." (IDI-03) "I like MATH-WAVE because it's not boring. There are lots of colors and activities. I feel happy when it's time for math." (IDI-04) "I became more excited to learn math because the activities were fun and interesting. I didn't feel bored, and I wanted to solve more problems to see if I could get them right." (IDI-06) "MATH-WAVE made me more excited about math. I enjoyed the games and activities, and they made me want to try my best. I like solving problems more now." (IDI-07)
Incorporating Interactive Strategies in Learning	"It would be better if there were more games and drawings so we could have more fun. It would also be great if we always used MATH-WAVE." (IDI-01) "It would be great if we had MATH-WAVE at home. We could also be given notebooks to practice. I also want more activities." (IDI-02) "Maybe we could add team games. It would also be great if we were given worksheets to work on at home." (IDI-03) "It would be better if we had MATH-WAVE every week. We should also be given paper to work on at home so we can learn more." (IDI-04) "I think MATH-WAVE can be better if we have more fun activities, group work, and maybe rewards when we do well. That would help the student like me and they will enjoy to solve problem-solving." (IDI-05) "I think MATH-WAVE can be better with more fun games, teamwork, and rewards when we do well. That would make students like me to enjoy in solve a problem." (IDI-07)

Realizing of the Importance of Problem-Solving

Understanding the value of problem-solving helps students appreciate math beyond just finding answers. When learners recognize that solving problems enhances their thinking and decision-making skills, they begin to engage more deeply in math tasks.

According to Valencia and Trucios (2021), guiding students to see the real-life relevance of math problems helps them build critical thinking skills and fosters a growth mindset. When students realize that math is more than tests and grades, they become more motivated to develop problemsolving strategies.

Similarly, Gomez and Santos (2022) noted that when learners are encouraged to reflect on the purpose of math activities, they become more analytical and thoughtful, leading to improved reasoning skills.
This aligns with the purpose of MATH-WAVE, which allows students to see how math problems connect to everyday thinking, making problem-solving more meaningful and relevant to their lives.

Improving Problem-Solving Approaches

Developing effective problem-solving strategies involves teaching students how to break problems into manageable parts, plan their solutions, and apply logical reasoning.

In line with this, Chen and Lim (2020) emphasized that scaffolding students with structured steps such as analyzing, planning, and checking fosters better comprehension and execution of math problems.

Also, Carvajal and Martinez (2023) found that learners perform better when taught how to visualize solutions and approach problems systematically rather than by guessing or skipping steps. The MATH-WAVE intervention promotes this through visual aids, drawing solutions, and encouraging step-by-step analysis, which helped Grade 4 learners become more confident and precise in their approach to solving word problems.

Boosting in Mathematical Confidence

Confidence in math is essential for success, especially when learners face challenges like word problems. Students who feel more capable are more likely to persist and succeed.

According to Dominguez and Rivera (2022), confidence in math improves when students receive continuous support, feedback, and opportunities to practice. This empowers them to attempt problems independently and with less fear of making mistakes.

Likewise, Singh and Jafar (2021) highlighted that learners who use technology and peer collaboration in math showed increased self-belief and were less hesitant to engage in complex tasks. MATH-WAVE's structured assistance, guided practice, and visual tools allowed students to build their confidence gradually, showing that with the right support, even previously fearful learners can approach math with greater courage and pride.

Increasing Enjoyment and Motivation in Math Learning

Enjoyment and motivation are crucial in sustaining engagement, particularly in subjects' students usually find difficult. Making math enjoyable leads to more frequent participation and a willingness to try.

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As Ryan and Deci (2020) affirmed, intrinsic motivation, sparked by fun and interest, encourages persistence and deeper learning in math.

Likewise, Wang and Lin (2022) found that colorful visuals, videos, and gamified learning environments increase students' enthusiasm and reduce negative feelings toward math.
MATH-WAVE's integration of games, visuals, and fun activities directly supported this outcome. Students reported that they looked forward to math sessions, remained active throughout, and developed a more positive attitude toward the subject.

Incorporating Interactive Strategies in Learning

Interactive strategies make math more engaging and student-centered. Using technology, group work, and hands-on tasks helps learners become active participants in their education.

Sibomana et al. (2021) observed that learners benefit from educational apps and platforms like GeoGebra, which improve understanding and maintain student interest.

Additionally, Umarova (2023) emphasized the value of combining teamwork, digital tools, and feedback to make learning more personalized and effective.
MATH-WAVE embraced this approach by allowing students to use technology, work in teams, and receive feedback while solving problems. The students' desire for more games, group activities, and take-home materials demonstrates how interactive strategies not only support learning but also promote greater engagement and satisfaction.

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