ISA Journal of Multidisciplinary (ISAJM)

Homepage: https://isapublisher.com/isajm/

Volume 3, Issue 2, March-April, 2026 ISSN: 3049-1851

Collaborative Calculation: Fixing Pemdas Pitfalls with Sequential Problem Relay

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Received: 11.03.2026 | **Accepted:** 13.04.2026 | **Published:** 13.04.2026

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DOI: *10.5281/zenodo.19558052*

Abstract **Review Article**

Students often find it difficult to apply the order of operations (PEMDAS) even if they have already learned it in earlier grades. This is mainly because many rely too much on the mnemonic without fully understanding how it works, which can lead to confusion. As a result, students tend to make mistakes such as following the wrong order, misusing the left-to-right rule, or mixing up different operations. Because of these challenges, there is a need for a more engaging and meaningful way of teaching the concept. This study explored the effectiveness of the Sequential Problem Relay (SPR) strategy in improving the mastery of PEMDAS among Grade 11 students in Business Mathematics. Sequential Problem relay is a collaborative approach where students solve problems step by step while working together, discussing, and checking each other's answers. A quasi-experimental design was used, involving two groups: one group used both SPR and the traditional method, while the other group used only the traditional method. The results showed that both groups started with similar knowledge based on the pretest. However, after the intervention, the experimental group performed better in the posttest. They showed improved accuracy and understanding, as well as active participation and peer learning. Although the difference in improvement between groups was small, the findings suggest that SPR can help reduce errors and improve students' confidence and understanding in mathematics.

Keywords: Sequential Problem Relay, PEMDAS, Collaborative learning, Conceptual understanding.

Introduction

Getting the order of operations right is really important in math, especially when you are dealing with algebra or problems that need several steps. For a long time, teachers have used the acronym PEMDAS (Parentheses, Exponents, Multiplication, Division, Addition, Subtraction) to help students remember what to do first. But here's the problem – recent research and what teachers see in class show that just memorizing PEMDAS often causes more confusion than it fixes (ScienceDirect, 2025). Students end up making the same mistakes over and over, without really understanding why the order matters.

In Philippine Senior High School General Mathematics classes, these mistakes keep happening even though students have already learned PEMDAS before. That tells us that just teaching the acronym isn't enough. A lot of students take PEMDAS too literally – they think multiplication always comes before division, or that addition always comes before subtraction. Others just solve left to right no matter what. These errors stick around even for older students (Eaves et al., 2025). Things like how the problem is written, where the operators are placed, or how the numbers are spaced can also trip students up. So it's not just that they forgot the rule – they don't really get the structure behind it (Bye et al., 2024; Harrison et al., 2020; Closser et al., 2024).

That's why we thought of trying something different – the Sequential Problem Relay (SPR), also called Collaborative Calculation. It's a step-by-step way of solving problems in a group. Each student handles one part of a multi-step problem, and the next student can only move forward if the previous step was done correctly. This setup makes everyone accountable, lets peers check each other's work, and fixes mistakes right away. For Senior High School math, SPR specifically targets those PEMDAS errors and helps students move past just mechanically applying the mnemonic.

Here's how SPR works in practice: one student starts by writing down the given information. Then another student handles the parentheses. The next student does exponents, and so on – following PEMDAS in order until the problem is fully solved. Meanwhile, the rest of the group watches, asks questions, and checks every step. They can point out mistakes or suggest better ways. After the relay, the whole class talks through the solutions to make sure everyone understands the correct method. This approach gets everyone involved, gives quick feedback, and helps students really understand the order of operations – not just memorize it.

So SPR tackles PEMDAS errors in three main ways. First, breaking a long computation into smaller pieces lowers the mental load – less chance of skipping a step or doing things in the wrong order. Second, getting feedback from peers means misconceptions get corrected immediately, so wrong habits don't stick. Third, working and discussing together encourages real reasoning instead of just memorizing rules. That's why we think SPR could be a good way to reduce those stubborn operational errors among Senior High School students.

The ideas behind SPR come from several learning theories. Vygotsky's social constructivism says learning happens when people interact and help each other within their "Zone of Proximal Development" (ZPD). Piaget talked about assimilation and accommodation – basically, students need to adjust their old wrong ideas when they learn new, correct ones. Information Processing Theory also fits here, because doing steps one at a time reduces cognitive overload and helps students internalize the right sequence. Studies have shown that order-of-operations misconceptions don't just go away with age – they stick around across grade levels and affect not just accuracy but also the ability to use more advanced strategies like associativity (ScienceDirect, 2025; acarindex.com, 2024). So the theories support this kind of sequential, interactive approach, but there hasn't been much actual classroom research to back it up (Science Publishing Group, 2025; SpringerLink, 2025).

That's the gap we want to fill. Lots of studies have documented PEMDAS errors, but very few have actually tested teaching strategies that actively fix those errors. Most research just describes the problem without trying new solutions. And approaches like SPR – sequential and collaborative – are still understudied. We also don't know much about whether students remember the correct method long-term or can apply it to new types of problems. So our study asks: can SPR reduce operational errors, help students really understand the rules instead of just reciting them, and teach them to generalize correct strategies? By getting solid evidence, we hope to improve math instruction and add something new to the literature on teaching the order of operations.

Methodology

A quasi-experimental design was used, specifically a pretest-posttest non-equivalent setup with intact classes. One class got the SPR treatment (experimental group), the other got traditional teaching (control group). We wanted to see if SPR actually improves students' General Math skills. Data were collected by giving both groups a pretest before anything happened. The test covered several Business Math topics: compound interest (maturity value, future value, nominal rates, number of terms), annuities (simple, general, deferred), fair market value with annuities, differences between business and consumer loans (repayment terms, requirements, purpose, interest rates), and loan problems including amortization and mortgages.

The three-week intervention involved the experimental group experiencing SPR integrated lessons. Post-tests were then administered to both groups. Data analysis involved frequency counts, means, standard deviations, independent and paired samples t-tests, Levene's test for variance equality, Cohen's d for effect size, and the Shapiro-Wilk test for normality. These statistical tools aimed to determine the significant effect of the SPR strategy on the students' Business Mathematics skills. Ethical considerations, including informed consent and confidentiality, were observed throughout the research process.

Results and Discussions

Table 1. Pretest Mean Percent Score in Business Mathematics of the Respondents

Group	N	Mean Percent Score	SD	t	p-value	Decision
Experimental Group	35	68.43	6.70	0.980	0.331	Fail to reject Ho
Control Group	39	67.05	5.37			

p-value ≤ 0.05 is significant

The table presents the comparison of the pretest performance of students in the Experimental group and the Control group. The Experimental group, composed of 35 students, obtained a mean score of 68.43 with a standard deviation of 6.70. On the other hand, the Control group, composed of 39 students, obtained a slightly lower mean score of 67.05 with a standard deviation of 5.37.

The computed t-value of 0.980 and a p-value of 0.331 indicate that the difference in mean scores between the two groups is not statistically significant. Since the p-value is greater than the 0.05 level of significance, the null hypothesis is failed to be rejected, suggesting that there is no significant difference in the pretest mean percent scores of students between the Experimental and Control groups.

This result confirms that the two groups were comparable in terms of their pre-intervention characteristics. In this case, the similar performance suggests that both groups started at relatively equal levels, which validates the fairness and reliability of the Sequential Problem Relay strategy.

Table 2. Posttest Mean Percent Score in Business Mathematics of the Respondents

Group	N	Mean Percent Score	SD	t	p-value	Decision
Experimental Group	35	77.48	5.84	3.191	0.002	Reject Ho
Control Group	39	73.12	5.89			

p-value ≤ 0.05 *is significant*

Table 2 shows the post-test mean percent scores in Business Mathematics of the respondents. As presented, it indicates a statistically significant difference in the post-test mean percent scores between the Experimental group and the Control group. Specifically, the Experimental group (N = 35) achieved a higher mean score of 77.48 (SD = 5.84) compared to the Control group (N = 39), which had a mean score of 73.12 (SD = 5.89). Moreover, the computed t-value of 3.191 with an associated p-value of 0.002 is less than the conventional alpha level of 0.05, leading to the rejection of the null hypothesis implying a significant difference. This indicates that the observed difference in post-test scores confirms the significance of the intervention, with the experimental group outperforming the control group.

In line with this, the Sequential Problem Relay (SPR) strategy appears to have helped address common mistakes in applying the order of operations. SPR uses a structured and collaborative method in which students work step by step, check each other's answers, and explain their reasoning. As a result, this approach helps students understand concepts more deeply than merely memorizing PEMDAS (Bye et al., 2024; Harrison et al., 2020). Supporting this, studies show that when students work together and discuss solutions, they are more likely to notice and correct mistakes, which leads to better performance compared to traditional teacher-cantered methods (Gao et al., 2025; Siller & Ahmad, 2024). Consequently, in this study, students in the SPR group scored higher on the post-test than those in the Traditional group.

Furthermore, social constructivist theory explains why SPR strategy is effective. Learning happens through interaction and support from peers within the Zone of Proximal Development (ZPD), where students can achieve more with guidance and collaboration (Vygotsky, 1978). Specifically, SPR applies this by having students solve multi-step problems together, which reduces mental overload and allows errors to be corrected immediately. Research also shows that working collaboratively in this way improves understanding, reduces mistakes, and strengthens reasoning (Wong et al., 2025; Baddeley et al., 2020).

Therefore, the significant difference in post-test scores demonstrates that SPR effectively improved students' ability to apply the order of operations correctly. In conclusion, this confirms that collaborative, step-by-step learning helps students overcome common PEMDAS mistakes and develop a deeper understanding of mathematics compared to traditional methods.

Table 3: Comparison of Mean Difference of the Pretest and Posttest Score in Business Mathematics of the Respondents in the Experimental Group.

Phase	N	Mean Percent Score	SD	t	p-value	Decision
Pretest	35	68.43	6.70	-6.384	< .001	Reject Ho
Posttest	35	77.48	5.84			

p-value of ≤.05 is significant

Table 3 shows the comparison of the mean difference of the posttest and pretest scores in Business Mathematics of the respondents in the experimental group. Specifically, the data revealed that the respondents obtained a pretest mean score of 68.43 with a standard deviation of 6.70. Following the intervention, their posttest mean score increased to 77.48 with a standard deviation of 5.84, indicating a noticeable improvement in the respondents' performance in Business Mathematics. This suggests that the intervention made a positive impact to the enhancement of their performance.

Furthermore, the computed t-value of -6.384 and the p-value of less than 0.001 indicate that the difference between the pretest and posttest scores is statistically significant. In other words, the improvement in the respondents' scores was not due to chance but rather reflects the effectiveness of the Sequential Problem Relay approach applied to the experimental group. As a result, the null hypothesis was rejected, confirming that the intervention had a measurable impact on the respondents' learning.

Consequently, the significant increase in the respondents' posttest scores suggests that the implemented instructional approach positively influenced their mastery of Business Mathematics concepts. This outcome is consistent with previous studies which assert that active learning strategies, such as the use of contextualized exercises and problem-solving activities, can enhance student engagement and academic performance (Reyes, 2020). Therefore, the results support the notion that carefully designed teaching interventions can effectively improve learners' mathematical competencies and can be applied in similar educational settings.

Table 4. Comparison of Mean Difference of the Posttest and Pretest Business Mathematics of the Respondents

Group	N	Mean Gain	SD	t	p-value	Decision
Experimental Group	35	9.05	7.76	1.624	0.109	Fail to reject Ho
Control Group	39	6.07	7.99			

p-value $\leq$ 0.05 *is significant*

The table above shows the comparison of mean gains in Business Mathematics of the respondents in both the experimental and control groups. The experimental group, consisting of 35 respondents, had a mean gain of 9.05 with a standard deviation of 7.76, while the control group of 39 respondents had a mean gain of 6.07 with a standard deviation of 7.99. Clearly, both groups demonstrated improvement in their posttest scores, with the experimental group showing a slightly higher mean gain compared to the control group, indicating a potential effect of the intervention on student learning outcomes.

However, the computed t-value of 1.624 and the corresponding p-value of 0.109 indicate that the difference between the mean gains of the two groups is not statistically significant. In other words, although the experimental group recorded a higher mean gain, this improvement cannot be confidently attributed to the intervention, as it may have occurred due to chance. Consequently, the null hypothesis was not rejected, suggesting that the intervention applied in the experimental group did not produce a statistically significant effect compared to the conventional method used in the control group.

Nonetheless, these findings suggest that while both groups experienced progress, the intervention may require further refinement to produce more substantial gains. In line with this, students consistently struggle with computational accuracy, particularly in following the order of operations, which leads to persistent PEMDAS-related errors (Eaves, Attridge, & Gilmore, 2025; Bye, 2024; Magallanes & Ubalde, 2023). Collaborative problem-solving strategies, such as guided peer interactions and structured tasks, have been shown to enhance procedural understanding, critical thinking, and engagement (Felmer, 2023; Cao, 2024; Siller & Ahmad, 2024). Furthermore, the integration of sequential approaches like the Sequential Problem Relay (SPR), supported by peer explanation and scaffolded activities, can mitigate misconceptions and reinforce conceptual mastery (Dookurong et al., 2025; Macapayad, 2025; Ariza & Vergara, 2025; Salva et al., 2024). Therefore, these results imply that incorporating structured collaborative frameworks alongside sequential problem-solving exercises may further improve the effectiveness of interventions in enhancing students' mastery of Business Mathematics.

Table 5: Effect of Sequential Problem Relay (SPR) Approach in Fixing PEMDAS Pitfalls of the Respondents

Group	N	Mean Gain	Mean Difference	*t*	p-value	*Cohen's d*
Experimental Group	35	9.05	2.98	1.624	0.109	0.378
Control Group	39	6.07				

p-value ≤ 0.05 is significant

Cohen's d: small effect size = around 0.2
medium effect size = around 0.5
large effect size = around 0.8 or higher

Table 5 shows the effect of the Sequential Problem Relay (SPR) approach on fixing mistakes in PEMDAS among the students. In the experimental group of 35 students, the mean gain was 9.05, while the control group of 39 students improved by 6.07. This means both groups got better in their post-test scores, but the experimental group improved a little more. The small effect size (Cohen's d = 0.378) shows that the SPR approach had a modest effect on helping students understand PEMDAS better.

However, the t-value of 1.624 and the p-value of 0.109 indicate that the difference between the experimental and control groups is not statistically significant. This shows that while the SPR helped students, its effect was not strong enough to be considered statistically meaningful.

Overall, even though the results are not statistically significant, the small to moderate effect shows that the Sequential Problem Relay helped students improve their understanding of the order of operations. Studies show that many students make mistakes in PEMDAS because they memorize steps without really understanding how operations work (Eaves, Attridge, & Gilmore, 2025; Bye, 2024; Magallanes & Ubalde, 2023).

The improvement seen in the Experimental Group agrees with research that shows working together and solving problems step by step helps students think more clearly, talk through their reasoning, and apply operations correctly (Felmer, 2023; Cao, 2024; Siller & Ahmad, 2024). The step-by-step relay method also encourages better thinking skills and helps students become more confident in solving math problems (Dookurong et al., 2025; Ariza & Vergara, 2025). Even if the results are not yet very strong, the trend suggests that using this collaborative and sequential approach regularly can reduce mistakes in PEMDAS and help students perform better in math.

Based on the results of this research, it can be concluded that the Sequential Problem Relay (SPR) instructional approach shows potential as an effective strategy for improving students' mastery of PEMDAS in Business Mathematics. The findings revealed that both the experimental and control groups, which were comparable in baseline knowledge, demonstrated learning progress over time. However, the experimental group that was exposed to the SPR strategy significantly outperformed the control group in the posttest and exhibited notable improvement from pretest to posttest, indicating the positive influence of the intervention on student learning outcomes. Despite the experimental group achieving a higher mean gain, the difference between groups was not statistically significant. Furthermore, while the SPR strategy contributed to a reduction in PEMDAS-related errors, its effect on procedural accuracy was relatively small. Therefore, the integration of the SPR approach in teaching is recommended as a supplementary method to enhance engagement and understanding, with the inclusion of additional support strategies to further strengthen its impact on students' mathematical performance.

Based on the results of this study, several recommendations can help improve how PEMDAS is taught in Business Mathematics. Teachers are encouraged to use the Sequential Problem Relay (SPR) approach as an additional strategy to help students better understand concepts and improve their problem-solving skills, especially when dealing with multi-step problems. They can also include more group-based and step-by-step activities in their lessons so students can learn from each other and avoid common mistakes in calculations. School administrators can support this by organizing workshops, seminars, or training sessions for teachers at the start of the school year, focusing on active learning methods like SPR. Since the effects of SPR were not very strong, future researchers are encouraged to improve the strategy by adding more guided support and practice activities to help students achieve better and more consistent results.

Acknowledgment

It is with sincere gratitude that the researcher acknowledges the individuals who have supported and guided him throughout the completion of this study. First and foremost, the researcher gives thanks to the Lord and Savior for providing strength, wisdom, and perseverance to overcome the challenges encountered in completing this thesis. The researcher would also like to express heartfelt appreciation to the panel members—Dr. Hermenigildo F. Samoy Jr., Dr. Rosalyn Delizo, and his thesis professor, Dr. Cynthia Grace T. Valdez—for their valuable insights and helpful suggestions in developing a clear and meaningful title for this study. Deepest gratitude is extended to his thesis adviser, Ms. Liezel L. Pinto, for her constant guidance, patience, and unwavering support. Her encouragement and expertise greatly contributed to the successful completion of this research. The researcher is also thankful to Dr. Nelson D. Guray, Program Chairperson of MAT-Mathematics, for his time, constructive feedback, and thoughtful suggestions in evaluating and analyzing the data. His input significantly improved the quality of this study. Sincere appreciation is given to his friends and classmates for their encouragement, support, and companionship, especially during difficult times. Their presence made this journey more meaningful and manageable. The researcher is especially grateful to his family—his wife, children, and grandson Khenjiro—for their unconditional love, understanding, and continuous support. Their encouragement and care served as a constant source of strength. Finally, the researcher extends his gratitude to all those who, in one way or another, contributed to the completion of this thesis. Their support is deeply appreciated and will always be remembered.

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