International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Rethinking Quadratic Equation Instruction: Evaluating the Po-Shen Loh Method's Effect on Students' Mathematical Knowledge

Jervis Russell J. Sajise[1], Ritzelda A. Deri[2]
[1]Sorsogon National High School, Sorsogon City, Sorsogon, Philippines 4700
[1, 2]Sorsogon State University, Sorsogon City, Sorsogon, Philippines 4700
Email address: sajisejervis@gmail.com, ritzeldaagnes2004@yahoo.com

Abstract*—This study investigated the effectiveness of the Po-Shen Loh method in solving quadratic equations using a quasi-experimental research design. Twenty-six student-respondents used the Po-Shen Loh method, treated as the experimental group, while another 26 student-respondents used the quadratic formula, assigned as the control group. Independent sample t-test results of the groups' post-test scores revealed statistically significant differences between the groups, with substantial practical impact, indicating that the experimental group using the Po-Shen Loh method showed a higher increase in performance on students' knowledge skill from "poor" to "very good" compared to the control group using Quadratic Formula who performed from "poor" to "fair". The results of this study suggest that using the Po-Shen Loh method in solving quadratic equations remarkably improves students' learning outcomes and experiences encompassing the knowledge skill. In pedagogical practice, this alternative method can address long-standing challenges in teaching and learning quadratic equations by introducing an innovative approach, such as another simplified method. This study provides an avenue for exploring the Po-Shen Loh method as a new approach to longstanding challenges in mathematics education, to improve learning.*

***Keywords*—** *Effectiveness, Knowledge Skill, Performance Level, Po-Shen Loh method, Quadratic Equation, Quadratic Formula*.

I. Introduction

Mathematics education is a cornerstone of education worldwide. Educators, school administrators, and curriculum planners continuously work to improve the quality of education, including mathematics. Despite the importance academic institutions place on mathematics, studies reveal that it remains the most challenging and hated subject by students around the world (Aguhayon et al., 2023; Akhter & Akhter, 2018; Chand et al., 2021).

The 2019 Trends in International Mathematics and Science Study (TIMSS) revealed that most of the eighty-four (84) participating countries are only reaching minimum proficiency in mathematics and emphasized the need for more professional development opportunities in integrating technology in teaching for teachers to improve students' performance (Mullis et al., 2020). Results from the 2022 Programme for International Student Assessment (PISA) also showed that 69% of the 15-year-old students participating in the assessment achieved minimum proficiency, and only 16 out of eighty-one (81) participating countries are considered high-performing in mathematics (ILSA-Gateway: PISA 2022 Results | ILSA-Gateway, n.d.). The PISA 2022 primary focus is mathematics, so these overall results can be alarming, where the Philippines generally scored below the baseline level of proficiency (level 2) in mathematics. Such facts provide insights into the depth of the country's educational system in preparing students for real-life problems and achievements, hence, demand improvements in educational delivery.

Moreover, mathematics education worldwide grapples with challenges in ensuring proficiency among learners in fundamental mathematical concepts such as quadratic equations. Quadratic equations are a significant subject area in secondary mathematics and are commonly included in international and national proficiency assessments. Like linear equations, quadratic equations serve as powerful representations of real-life situations, helping to solve many of the world's problems. The applications of quadratic equations are often helpful in other disciplines, such as physics, engineering, and design (Didis & Erbas, 2015). Conventionally, the factorization, extracting the square root, completing the square, and quadratic formula approaches are the four most broadly used methods of solving the roots of quadratic equations (Harripersaud, 2021).

Globally, even in the Philippines, teachers expressed that the students are not performing well in solving quadratic equations because they find it difficult to understand the behavior of the quadratic formula and functions (Kim How et al., 2022; Nielsen, 2015; Pentang et al., 2024; Tonui et al., 2022). Some teachers attributed the student's difficulty in solving quadratic equations to the limited flexibility teachers have in teaching the concepts and functions of quadratic equations (Reid O'Connor & Norton, 2024). Often, teachers are only allocated a short amount of time to cover this topic, which limits them from going into the topic deeply to foster student competency and fluency (Kabar, 2023; Merle, 2024).

However, these old problems can be addressed with a fresh perspective. While working on mathematical explanations for advanced concepts for young students, Dr. Po-Shen Loh, a mathematics professor at Carnegie Mellon University, worked on different ways of solving quadratic equations when he discovered a more straightforward method derived from clever manipulation of the completing the square technique in solving quadratic equations (Loh, 2021). The Po-Shen Loh method of solving quadratic equations involves transforming a quadratic

Jervis Russell J. Sajise and Ritzelda A. Deri, "Rethinking Quadratic Equation Instruction: Evaluating the Po-Shen Loh Method's Effect on Students' Mathematical Knowledge," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 8, Issue 10, pp. 92-96, 2026.

equation into a form where one side is a perfect square trinomial, making it easier to isolate the variable and find its solutions. The final Po-Shen Loh formula (1) $x = -\frac{B}{2} \pm \sqrt{\frac{B^2}{4} - C}$, was derived from the equation of the quadratic formula (2) $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$. They may look like similar, however, Po-Shen Loh formula's derivation through completing the square emphasizes the underlying logic and minimizes rote memorization. Considering the quadratic equation in the form of $x^2 + Bx + C = (x - r)(x - s)$, where r and s are the sum of $-B$ and product C, then r and s are all the roots of the quadratic equation. Procedurally, Loh (2021) provided the following steps as proof of the derived formula for the Po-Shen Loh method:

1. Two numbers sum to $-B$ when they are $-\frac{B}{2} \pm u$.
2. Their product is C when $\left(-\frac{B}{2}\right)^2 - u^2 = C$.
3. The square root always gives a valid u.
4. Thus $-\frac{B}{2} \pm u$ work as r and s, and are all the roots.

Computationally, the value of x makes the product equal zero precisely when at least one of the factors becomes zero in the given factorization form $x^2 + Bx + C = (x - r)(x - s)$, which happens precisely when $x = R$ or $x = S$. It suffices to find two numbers R and S with sum $-B$ and product C where $\{R, S\}$ is the complete set of roots. While $-\frac{B}{2}$ represents the average of R and S, and z is any single unknown quantity, so it suffices to find two numbers in the form of $-\frac{B}{2} \pm z$, which multiply to C. The product $(-\frac{B}{2} + z)(-\frac{B}{2} - z)$ conveniently matches the sum and difference of the squares, and equals C precisely when $\left(-\frac{B}{2}\right)^2 - z^2 = C$, or equivalently satisfies $z^2 = \left(-\frac{B}{2}\right)^2 - C$. The square root of $\frac{B^2}{4} - C$ to serve as z that satisfies the last equation. Finally, the desired R and S exist in the form $-\frac{B}{2} \pm z$, and so $-\frac{B}{2} \pm \sqrt{\frac{B^2}{4} - C}$.

Loh claimed that his derivation can demystify quadratic equations as it is computationally straightforward and conceptually natural, making it easier to use than the traditional quadratic formula and lessening the guess-and-check factoring game students play when solving quadratic equations (Loh, 2019). Considering the potential of this new method of solving quadratic equations that would address students' difficulties related to quadratic equations, the researcher aimed to test the effectiveness of the Po-Shen Loh formula as a shorter and simpler, yet effective way of solving quadratic equations.

Finally, the pressing need for innovative ways and novel methods presents an opportunity to explore alternative pedagogical approaches that could enhance students' mathematical skills. The investigation on the effectiveness of the Po-Shen Loh Method is in harmony with the context of the MATATAG curriculum. It sought to address existing gaps that might contribute to the ongoing efforts to elevate the quality of mathematics education in the Philippines and beyond.

II. Objectives of the Study

The study aimed to determine the effectiveness of the Po-Shen Loh Method in solving Quadratic Equations, conducted at Sorsogon National High School, Department of Education (DepEd) City Division of Sorsogon for SY 2024-2025. Specifically, it seeks to gauge the effectiveness of the Po-Shen Loh Method in improving the performance level of students' knowledge skill.

III. Methodology

A. Research Design

This study used quasi-experimental research to investigate the effectiveness of the Po-Shen Loh method compared to the traditional quadratic formula for solving quadratic equations. It is intended to establish the causal relationship between an intervention and its outcomes. It does not involve random assignment of participants since groups are pre-existing or assigned based on non-random criteria, such as location, demographic characteristics, or convenience (Hassan, 2024). The study employed pretests and posttests to gauge the effectiveness of the Po-Shen Loh method compared to the quadratic formula. Price et al. (2017) explained that the pretest-posttest design can be used in studies with pre-existing groups that cannot be randomly assigned. This design involves a treatment group that is given a pretest, exposed to a treatment (use of the Po-Shen Loh method), and then given a posttest. At the same time, a control group is also given a pretest, not exposed to a treatment (using the traditional quadratic formula method), and a posttest. This design underscores whether the experimental group improves significantly more after receiving the treatment than the control group. Possible outliers were identified using statistical methods and contextual considerations. Transparency in reporting and justifying decisions on possible outliers is discussed in the discussion and analysis of results. The quasi-experimental design, while not allowing for the most robust causal inferences due to the lack of individual-level random assignment, offers a practical way to compare the two methods within the constraints of the existing classroom structure.

B. Research Locale and Participants

This study utilized two (2) homogeneous groups of participants assigned to control and experimental groups; each class has 26 student-participants. The Grade 9-Prudence, the control group, and Grade 9-Wisdom, the experimental group, enrolled at Sorsogon National High School for SY 2024-2025, taking lessons on quadratic equations as part of the Grade 9 mathematics curriculum. The control group (Grade 9-Prudence) used the traditional quadratic formula to find the roots of quadratic equations, while the experimental group (Grade 9-Wisdom) employed Po-Shen Loh as an alternative method for solving quadratic equation roots. This setup was established to isolate the effects of the intervention and determine the effectiveness of the Po-Shen Loh method in solving quadratic equations.

C. Research Instrument

Jervis Russell J. Sajise and Ritzelda A. Deri, "Rethinking Quadratic Equation Instruction: Evaluating the Po-Shen Loh Method's Effect on Students' Mathematical Knowledge," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 8, Issue 10, pp. 92-96, 2026.

The researcher developed a 15-item multiple-choice test type that was utilized for a pretest and posttest in solving the roots of the quadratic equations, intended to measure students' knowledge skill performance level. It underwent validation from three (3) subject matter experts teaching mathematics for at least seven (7) years, who have post-graduate degrees, and hold master teacher and supervisor positions. The instrument was also pilot-tested. The result of the validation of the test instrument using the validation research instrument by Good and Scates (1972) suggests positive feedback, with an overall mean rating of $\bar{x} = 4.69$, indicating that the items for the knowledge test have relevance and depth, and are appropriate items to measure the performance level of the students. The test instrument also went through the reliability testing, using Cronbach's alpha coefficient. The result of the conducted pilot testing showed a high Cronbach's alpha of α=0.960, which empirically suggests that the researcher-developed test is a reliable instrument for measuring students' performance levels in solving quadratic equations. The validation of the test instrument provides confidence in the validity of the findings based on this scale. The test scores derived from the researcher-developed test assessed the students' initial performance level and the effect of identified methods for solving quadratic equations on their knowledge skill after the intervention stage.

D. Data Gathering Procedure

The researcher prepared the necessary documents to seek approval to conduct this study in the school, including a communication letter to the Office of the Schools Division of the Superintendent of DepEd Sorsogon City. Informed consent was also obtained from the student respondents and their parents or guardians before the study implementation.

The study was conducted during the first quarter of the School Year 2024-2025. The instruction period focused on solving quadratic equations, and the Po-Shen Loh method was integrated into the lesson for the experimental group as an alternative method for finding the roots of quadratic equations. In contrast, the control group used the traditional quadratic formula included in the curriculum. Pretest and posttest were administered to the control and experimental groups before and after the intervention to determine the effectiveness of the intervention.

Finally, upon the completion of the research experiment, the alternative approach (Po-Shen Loh method) and other conventional ways (factoring, extracting the square root, and completing the square) of solving quadratic equations were introduced to both groups.

E. Data Analysis

Since the difference in the scores of pre-test and post-test results of the experimental and control groups is found to be not normally distributed using the Shapiro-Wilk test, the Wilcoxon W is employed. The Wilcoxon W test is used to analyze the data from a repeated-measures design when the data do not meet the requirements for a parametric test (University of Sussex, n.d.). The mean, standard deviation, significance level, Wilcoxon W test, Cohen's d, as well as percentage score (Juvrianto et al., 2018) were utilized to determine the significant difference in the students' knowledge skill performance levels between the pre-test and post-test scores for each group.

The data sets gathered on students' post-test scores were subjected to the Shapiro-Wilk test, which showed the normality of the distribution of students' knowledge skill performance levels between the experimental and control groups. These data are statistically treated and analyzed through the mean, standard deviation, significance level, t-test, Cohen's d, as well as percentage score with its corresponding score description (Juvrianto et al., 2018) below:

Percentage Score	Description
100-96	Excellent
95-86	Very Good
85-76	Good
75-66	Fairly Good
65-56	Fair
55-36	Poor
35-0	Very Poor

F. Ethical Consideration

Ethical principles are observed in the conduct of this study. Respondents participated voluntarily and ensured that their identities and responses were kept confidential. Data were gathered without coercion or incentives and utilized solely for academic purposes. The study adhered to the ethical guidelines set by Sorsogon State University and followed standard practices for educational research.

IV. Results and Discussions

The effectiveness of an alternative approach (Po-Shen Loh method) in solving quadratic equations is the central theme of this study. For this study, the experimental group used the Po-Shen Loh method, while the control group was taught to use the quadratic formula to solve quadratic equations. The researcher studied the students' performance level before and after the instruction period to compare the effectiveness of both methods. Andress and Winterfeld (2013) stated that measuring the performance level is a reliable way to assess the effectiveness of a process or method.

Knowledge Skill. The tables below present the comparative non-normal pre-test and post-test performance of the student-respondents of the control and experimental groups, as well as the groups' comparative normally distributed post-test performance.

Basically, the presented pre-test results in Table 1 indicate that the mean scores of the experimental group and control group have obtained a poor performance level. The low-level spectrum (Poor) in the pretest reflects previously cited studies claiming that solving quadratic equations is one of the most challenging and least mastered competencies in junior high school mathematics (Güner, 2017; Herawaty et al., 2021; Pentang et al., 2024). After the conduct of this study, the knowledge skill performance level revealed a significantly

Jervis Russell J. Sajise and Ritzelda A. Deri, "Rethinking Quadratic Equation Instruction: Evaluating the Po-Shen Loh Method's Effect on Students' Mathematical Knowledge," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 8, Issue 10, pp. 92-96, 2026.

higher increase in the experimental group from 40.3% (Poor) to 92.3% (Very Good) with large effect size (Cohen's d=0.88), as well as in the control group from 39.7% (Poor) to 58.2% (Fair) both with $p<0.001$ lower than the significant level and large effect size (Cohen's d=0.89). The significant differences in the pre-test and post-test scores translate to an outstanding performance of the experimental group and a reasonably satisfactory performance of the control group. Inferentially, using the traditional approach (quadratic formula) and the alternative way (Po-Shen Loh method) are both effective in solving quadratic equations. This simply implies that the alternative (Po-Shen Loh Method) and traditional (Quadratic Formula) approaches are acceptable in solving quadratic equations, both positively contributed to an increase in students' knowledge skill level.

TABLE 1: Difference in the Pre-Test and Post-Test Performance Level of the Experimental Group and Control Group

Statistics	Experimental Group		Control Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Percentage Score	40.3%	92.3%	39.7%	58.2%
Description	POOR	VERY GOOD	POOR	FAIR
$\bar{x}$	6.04	13.85	5.96	8.73
SD	2.84	1.99	1.59	1.90
Wilcoxon W (z-test)	4.48		4.56	
significance level	0.05		0.05	
p-value	0.00 (<0.001)		0.00 (<0.001)	
Decision (Ho)	Reject		Reject	
Conclusion	Significant		Significant	
Cohen's d	0.88		0.89	

TABLE 2: Difference in Knowledge Skill based on the Post Test Performance Level of the Experimental Group and Control Group

Statistics	Post-Test	
	Experimental Group	Control Group
Percentage Score	92.3%	58.2%
Description	VERY GOOD	FAIR
$\bar{x}$	13.85	8.73
SD	1.99	1.90
significance level	0.05	
t-test	9.12	
p-value	0.00 (<0.001)	
Decision (H_o)	Reject	
Conclusion	Significant	
Cohen's d	0.95	

Table 2 presents the performance level in knowledge skill of student-participants after the instruction period, as shown in the post-test scores. The results showed a statistically significant difference in the effectiveness of the Po-Shen Loh Method in improving students' performance in solving quadratic equations compared to the control group.

The results indicate that the Po-Shen Loh method yields a more significant knowledge skill performance in solving quadratic equations compared to the traditional formula. The higher mean ($\bar{x} = 13.85$) and smaller standard deviation (SD=1.99) of the post-test scores of the experimental group imply greater consistency in the positive effect of the Po-Shen Loh method on students' performance. At the same time, the large t-value ($t(50) = 9.12$), very small p-value ($p < 0.001$), and high positive correlation (Cohen's d=0.95) in the post-test results, provide strong evidence of the effectiveness of the Po-Shen Loh method in increasing students' knowledge skill in understanding concepts and gaining mastery in solving quadratic equations compared to the use of traditionally known quadratic formula.

These findings are consistent with the studies by Reid O'Connor and Norton (2024) and Loh (2019) on the potential of the Po-Shen Loh Method to provide students with a more straightforward approach to solving quadratic equations, making it more understandable. The improvement in students' performance in solving quadratic equations when using the Po-Shen Loh method can be attributed to the method's flexibility and simplicity in manipulating the completing the square technique, which is otherwise challenging to many students (Loh, 2021). Studies show that contemporary learners prefer to use simplified methods and shortcut-based strategies to reduce cognitive effort and improve performance (Godau et al., 2014; Sehl et al., 2024). With its emphasis on completing the square and simplicity of the process, the Po-Shen Loh method can help students understand the underlying concepts of quadratic equations while reducing cognitive load, making it easier for students to apply or execute the method effectively.

Finally, the performance levels of student-participants before and after the instruction period suggest that both methods can improve students' performance in solving quadratic equations. A closer examination of the results reinforces Merle's (2024) assertion that, although traditional pedagogical approaches to solving quadratic equations remain practical, a more innovative approach is necessary in this area to achieve student proficiency. Similar results transpired in Table 2 signify that while the traditional method of solving quadratic equations (the quadratic formula as used by the control group) is enough to obtain the minimum performance level to pass the subject or lesson, the use of the Po-Shen Loh method appears to be more contributive in improving students' performance in solving quadratic equations. This demonstrates the potential of the Po-Shen Loh method to address the difficulties students encounter when solving quadratic equations.

V. Conclusion and Recommendation

The study found that it does not matter which method a student uses for solving quadratic equations since instruction is effective in improving students' understanding and performance levels. However, the Po-Shen Loh method is proven to be more effective in improving students' knowledge skill than using the quadratic formula. This study highlights how an innovative method like the Po-Shen Loh can enhance students' learning by integrating such a method into instructional practices. Teachers can help their students develop a deeper understanding of the underlying concepts of quadratic equations and overcome challenges in solving quadratic equations. These findings point out that the use of the Po-Shen Loh method is worthy of the attention of makers and school administrators in advancing mathematics education.

Jervis Russell J. Sajise and Ritzelda A. Deri, "Rethinking Quadratic Equation Instruction: Evaluating the Po-Shen Loh Method's Effect on Students' Mathematical Knowledge," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 8, Issue 10, pp. 92-96, 2026.

Based on the valuable insights from the findings and conclusions of this study, the following recommendations stipulate that effective integration and exploration of the Po-Shen Loh method as a complementary or alternative approach to teaching quadratic equations in the mathematics curriculum, subject to harmonizing the policy with 21st-century learning competencies. The study recommends that the Po-Shen Loh method be integrated as a strategy for teaching quadratic equations to improve students' knowledge skill, especially the academically challenged students who poorly perform in solving quadratic equations using traditional methods.

An innovative intervention materials, titled Project *MA-KNOW PO-SHEN*: Reimagining Quadratics through the Integration of the Po-Shen Loh Method, is being proposed by the researcher based on the findings of this study. Project MA-KNOW PO-SHEN, as a proposed intervention learning materials, stands for 'Innovative Materials for Motivation, Knowledge, and Process of Po-Shen Loh Method in Solving Quadratic Equation'. The utilization of the Po-Shen Loh method materials in teaching and solving quadratic equations will also be submitted for acceptance as learning or reference materials under the Learning Resource Program (LRP) of the Department of Education (DepEd).

ACKNOWLEDGMENT

The researchers would like to express their gratitude to the Sorsogon State University Graduate School (SSU-GS) and the Grade 9 STE learners of Sorsogon National High School. Special thanks are extended to the GS Dean, Dr. Susan S. Janer, and the University President, Dr. Geraldine F. De Jesus, from SSU. Additionally, appreciation is extended to the Schools Division Superintendent, Dr. William E. Gando; Dr. Elena D. Hubilla, the Curriculum Implementation Division (CID) Chief Education Supervisor; and Mr. Ruel G. Frago, the Division Mathematics Coordinator (DMC) from the Schools Division Office of Sorsogon City. The researchers are thankful to all the individuals who contributed to the realization of this study.

REFERENCES

[1] H. Aguhayon, R. Tingson, and J. Pentang, "Addressing students learning gaps in mathematics through differentiated instruction," *International Journal of Educational Management and Development Studies*, vol. 4, no. 1, pp. 69–87, 2023.

[2] N. Akhter and N. Akhter, "Learning in mathematics: Difficulties and perceptions of students," *Journal of Educational Research*, vol. 21, no. 1, 2018.

[3] S. Chand, K. C. Chaudhary, A. Prasad, and V. Chand, "Perceived causes of students' poor performance in mathematics," *Frontiers in Applied Mathematics and Statistics*, vol. 7, 2021.

[4] I. V. Mullis, M. O. Martin, P. Foy, D. L. Kelly, and B. Fishbein, *TIMSS 2019 International Results in Mathematics and Science*. Boston College, TIMSS & PIRLS International Study Center, 2020.

[5] Organisation for Economic Co-operation and Development, *PISA 2022 Results: Country Notes – Philippines*. Paris: OECD Publishing, 2023.

[6] M. G. Didis and A. K. Erbas, "Performance and difficulties of students in formulating and solving quadratic equations," *Educational Sciences: Theory and Practice*, vol. 15, no. 4, pp. 1137–1150, 2015.

[7] A. Harripersaud, "The quadratic equation concept," *American Journal of Mathematical Sciences*, vol. 11, no. 3, pp. 68–72, 2021.

[8] R. P. T. Kim How, H. Zulnaidi, and S. S. Abdul Rahim, "Higher order thinking skills in quadratic equations: Teaching practices and challenges," *European Journal of Science and Mathematics Education*, vol. 10, no. 1, pp. 15–33, 2022.

[9] L. E. J. Nielsen, *Understanding quadratic functions and solving quadratic equations: An analysis of student reasoning*. Ph.D. dissertation, University of Washington.

[10] J. Pentang, L. J. Andrade, J. Golben, J. Talua, R. Bautista, and J. Sercenia, "Problem-solving difficulties and performance in mathematics among preservice teachers," 2024.

[11] G. K. Tonui, L. Ayiro, and K. Ongeti, "Learner difficulties in solving word and graphical problems in quadratic equations," *International Journal of Recent Research in Physics and Chemical Sciences*, vol. 8, no. 2, pp. 13–25, 2022.

[12] B. Reid O'Connor and S. Norton, "Exploring the challenges of learning quadratic equations," *Mathematics Education Research Journal*, vol. 36, no. 1, pp. 151–176, 2024.

[13] M. G. D. Kabar, "A thematic review of quadratic equation studies," *Participatory Educational Research*, vol. 10, no. 4, pp. 29–48, 2023.

[14] R. S. Merle, "Enhancing proficiency in quadratic equations and functions," *Journal of Contemporary Educational Research*, vol. 8, no. 1, pp. 221–232, 2024.

[15] C. Godau, A. Schubö, and T. J. Faulkenberry, "The role of shortcut strategies in mathematical problem solving: Evidence from students' strategy selection and performance," *Journal of Numerical Cognition*, vol. 1, no. 1, pp. 3–21, 2014.

[16] J. Sehl, T. Lombrozo, and N. Vasilyeva, "People prefer simpler explanations and processes when statistical information is absent," *Cognitive Psychology*, vol. 150, p. 101674, 2024.

[17] P. S. Loh, "Quadratic Method: A simple approach to solving quadratic equations," 2021.

[18] P. S. Loh, "A simple proof of the quadratic formula," *arXiv preprint arXiv:1910.06709*, 2019.

[19] M. Hassan, "Quasi-experimental research design: Types and methods," 2024.

[20] P. C. Price, R. S. Jhangiani, I. A. Chiang, D. C. Leighton, and C. Cuttler, *Research Methods in Psychology*. BCcampus Open Education, 2017.

[21] University of Sussex, "The Wilcoxon Signed-Rank Test," Statistical Methods Handout, 2011.