ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Vol 11, Issue 11, November 2024

Factoring Quadratic Trinomials: An Analysis of Students' Performance Utilizing the X-Box Method

[1] Karl A. Puertollano

[1] Iloilo Science and Technology University Burgos St., La Paz, 5000 Iloilo City
Corresponding Author Email: [1] karl.puertollano4444@gmail.com

Abstract*— - The research objective is to determine the effectiveness of the X-Box Method in factoring quadratic trinomials. The participants were 100 Mandurriao National High School grade 8 students divided into control and experimental groups. The respondent in each group is matched according to their pretest result. The control group in the study used the sum and product method, whereas the experimental group utilised the X-Box method. The data collected were analysed with the aid of SPSS. Specifically, the mean, standard deviation, dependent-samples T-test, and Independent-samples T-test were employed. The results revealed that learners' performance was below average before the intervention, and both interventions helped improve students' performance. Compared to the sum and product method, the X-Box method improved. Suggesting that the X-Box method may be particularly beneficial for learning. However, there is no significant difference in the post-test results of both methods.

Index Terms: X-box Method, Factoring Quadratic Trinomials, Students' Performance.

I. INTRODUCTION

Factoring quadratic trinomials is a fundamental skill in algebra, essential for solving quadratic equations and simplifying expressions. According to Villanueva et al. (2022), factoring quadratic trinomials, which requires rewriting $ax^2 + bx + c$ into the form $(mx + n)(px + q)$ is one of the most difficult algebraic challenges for students in the high school Mathematics curriculum. One innovative technique that has gained attention in recent years is the X-Box method. This method provides a structured and visual approach to factoring, potentially enhancing students' understanding and performance. Teaching mathematics, viewed as unappealing to most learners, can be challenging in mixed-ability classrooms and need help with their interests and experiences (Mavrotheris, 2014).

Students are frequently frustrated by the conventional approaches to factoring quadratic trinomials, such as trial and error or the AC technique, especially when dealing with complex coefficients. Studies have shown that learners with a researcher-made module featuring the X-Box method performed better than learners with modules used by the school for the distance learning modality (Villanueva et al., 2022). This technique provides a more intuitive approach to the solution by methodically breaking down the middle term and finding pairs of variables by creating a box diagram.

Alongside these advantages, however, it still carries several limitations. For instance, a study by Norton (2022) shows that students emphasised that difficulties with critical prerequisite concepts such as algebraic conventions impeded students' success in understanding and working with quadratics. The findings result from limited time frames nominated for learning quadratic topics outlined in the enacted curriculum. This paper seeks to analyse the productivity and performance of students when incorporating the X-Box Method into their work. The proponents will further explore this paper's challenges, providing insights into the practical application of the X-Box method in educational settings.

II. LITERATURE REVIEW

A. Traditional Factoring Methods

The quadratic formula was a remarkable triumph of early mathematicians, marking the completion of a long quest to solve quadratic equations, with a storied history stretching as far back as the Old Babylonian Period (Katz, 2008). According to Loh (2019), before learning the quadratic formula, students learn how to multiply binomials, and they see function expansions such as $(\boldsymbol{u} + \boldsymbol{v})^2 = \boldsymbol{u^2} + \boldsymbol{2uv} + \boldsymbol{2}$ ***and*** $(\boldsymbol{u} + \boldsymbol{v})(\boldsymbol{u} - \boldsymbol{v}) = \boldsymbol{u^2} - \boldsymbol{v^2}$. The author also noted that the first of these expansions is the cornerstone of the traditional proof of the quadratic formula by completing the square.

The AC method is universally known. In a study by Mallick (2012), the author tested the First In, First Out (FOIL) Method and the AC-Test Method to factor the quadratic trinomial functions into two factors. Results show that the FOIL method found four parameters directly that satisfy three different constraints. The number of parameters to be found exceeds the number of constraints; the system must be consistent. There is no alternative to the trial-and-error method to find the required parameters.

Meanwhile, the AC-test method finds two parameters, and they meet two constraints. The parameters and constraints are equal; hence, the system is consistent (identified) and has a unique solution for the required parameters. The author also mentioned that this simple fact was overlooked for centuries, and we still practise the trial-and-error method to find them.

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Vol 11, Issue 11, November 2024

B. Introduction and Impact of the X-Box Method

In mathematics, multiple approaches are considered when solving a problem. According to Zalesny (2011), the Gelosia method was employed extensively and is still used today. This method differs from long multiplication because it divides multiplication and addition into two phases. Tracing back its origin from India, this organisational multiplication method allows numbers to be multiplied visually, using a lattice-looking diagram. As of today, this method is known as the X-Box Method. This technique significantly made its way to Europe during its earlier days. Fibonacci brought it to Europe with his 1202 book Liber Abacii.

The X-Box method uses a modern method of teaching factoring to students, whereas it provides a structured system of breaking down quadratic trinomials. The technique entails creating an organised grid to find pairs of factors and understand their coefficients. According to Obongen et al. (2020), the X-Box method is an alternative to long multiplication for numbers. The X-box method in the Multiplication of Polynomials is an extension of multiplying numbers. In this method, the products in terms of polynomials are inside the boxes, not just numbers or coefficients. A lattice is first constructed and sized for the approach to fit the multiplied numbers. If we multiply an m-digit number by an n-digit number, the size of the lattice is m x n. The study found that introducing the box method to the students significantly enhanced their overall performance when multiplying polynomials.

C. Challenges and Practical Applications

Despite its advantages, the X-Box method has challenges. Teachers note difficulties when teaching the technique; some students need help to follow it quickly. A study by Refugio et al. (2022) investigated the challenges encountered and strategies employed by Grade 11 teachers when teaching. Results have shown that the Grade 11 teachers are well equipped when teaching the course; the only downside is that some need better time management skills and more content mastery. Teachers were also observed acknowledging the students' perspectives to address challenges. However, it was also noted that teachers applied no strategy to overcome difficulties in teaching because they needed more time to reach this competency. Instead, they only introduced an overview of the lesson. They were not able to elaborate and discuss further. This signifies that teachers must manage their time teaching all the course competencies.

Furthermore, some students may need help to meet the conceptual understanding requirements of the X-Box technique. Students may find the visual arrangement too complex or need to recognise its benefits over more straightforward approaches if given the right direction. In a study by Slaavik (2018), the author explored the relations between students' prior grades in mathematics, achievement goal orientations in mathematics classes, anxiety, and students' coping strategies. Results showed that prior performance-avoidance goal orientation predicted higher stress levels and more use of self-protective coping strategies. Furthermore, the analysis showed no evidence that a performance-avoidance goal orientation would reduce the students' use of problem-focused coping strategies. A performance-approach goal orientation was practically unrelated to the coping strategies.

III. PURPOSE OF THE STUDY

The research objective is to determine the effectiveness of the X-Box Method to factor quadratic trinomials. Specifically, it seeks to answer the following questions:

1) What is the performance level of the learners in factoring quadratic trinomials before and after the intervention?
2) Is there an increase in the learners' post-test mean scores when exposed to two different interventions?
3) Is there a significant difference between the performance of control and experimental groups after the intervention?

IV. SIGNIFICANCE OF THE STUDY

This study may benefit educators and curriculum developers.

V. METHODOLOGY

A. Research Design

The quasi-experimental design (The Matching-Only Pretest - Post-test Control Group Design) was employed in this study. Quasi-experimental designs do not use random assignment (Fraenkel et al., (2012).

Table I: The Matching-Only Pretest – Post-test Control Group Design

Quasi-Experimental	Pretest	Control Group (Matched based on pretest results)	Sum and Product Method	Post-test
		Experimental Group (Matched based on pretest results)	Intervention (X-Box Method)	Post-test

B. Participants

The research included one hundred (100) grade 8 students from four sections of Mandurriao National High School. They were evenly divided into two groups, matched based on their pretest results: the Control Group and the Experimental Group.

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Vol 11, Issue 11, November 2024

C. Research Instrument

The data-gathering instrument used was validated. Based on this, the questionnaire was administered in paper-and-pen format.

D. Data Gathering Procedure

This study has three stages. The first stage is administering a pre-test. Fifty pairs of students are matched according to their pretest scores from control and experimental groups. Second, they must carry out the intervention activity in their classes. The Control Group used the sum and product method, while the Experimental Group received an intervention utilising the X-Box method. Lastly, the post-test was administered.

E. Data Analysis

The collected data were analysed using the Statistical Package for the Social Sciences. Specifically, it utilised the mean and standard deviation to determine the learners' performance levels in factoring quadratic trinomials before and after the interventions. Furthermore, a paired-sample t-test was used to determine whether there was an increase in the post-test mean scores of the two groups when exposed to two different interventions. Lastly, an independent-sample t-test was employed to determine the significant difference in the post-test mean scores of the two groups.

VI. RESULTS AND DISCUSSION

In this segment, the data gathered from both the pre-test and post-test phases underwent analysis and subsequent presentation. The outcomes and the corresponding analysis and interpretation of the study's challenges are presented.

Table II: The Pretest and Post-test Mean Scores of Controls and Experimental Groups.

Group	Mean	Standard Deviation	Description
Control			
Pretest	6.14	1.57	Below Average
Post-test	8.46	4.10	Average
Experimental			
Pretest	6.14	1.57	Below Average
Post-test	9.94	3.55	Average

Legend: Low Average	0.00 – 6.67
Average	6.68 – 13.34
Above Average	13.35 – 20

Table 1 provides the mean results of the pretest and post-test. The pretest scores of the learners served as the foundation for matching two groups – the control and experimental groups. Fifty pairs of students are matched for this study. Furthermore, the control and experimental groups obtained a mean score of 6.14 (SD = 1.57), described as below average before the intervention. Moreover, after the intervention, the control group obtained a mean score of 8.46 (SD = 4.10), which is described as average. At the same time, the experimental group obtained a mean score of 9.94 (SD = 3.55), also described as average.

Table III: Dependent-Samples T-test of Controls and Experimental Groups

Group	Mean	Mean Difference	t – value	df	Sig (2-tailed)	Confidence Level	
						Lower	Upper
Control							
Pretest	6.14	-2.320	-4.501	49	.000	-3.356	-1.284
Post-test	8.46						
Experimental							
Pretest	6.14	-3.800	-7.730	49	.000	-4.788	-2.812
Post-test	9.94						

Table 2 shows the results of the dependent-sample T-test between the pretest and post-test results of two groups – the control and experimental groups. The data revealed a significant difference (p = 0.000 and p = 0.000) in the two groups' pretest - post-test mean scores when exposed to two interventions. It appears that the pretest mean score of the control group is below average (M = 6.14), while the post-test mean score is average (M = 8.46). Moreover, it appears that the pretest mean score of the experimental group is below average (M = 6.14), while the post-test mean score is average (M = 9.94). Thus, both groups improved their performance after they were exposed to two different interventions.

However, the mean difference of 3.800 of the experimental group compared to 2.320 of the control group showed that the experimental group improved better than the control group. The result aligns with the study conducted by Villanueva et al. (2022), which found that the X-box method effectively factored quadratic trinomials.

Table IV: The Test of Significant Difference between The Post-Test Mean Scores of Controls and Experimental Groups

Group	Mean	Mean Difference	t – value	df	Sig (2-tailed)	Confidence Level	
						Lower	Upper
Control	8.46	-1.480	-1.931	98	0.056	-3.001	0.041
Experimental	9.94						

Table 3 shows the independent-sample T-test result on the two groups' post-test mean scores. There is no significant difference (p = 0.056) between the two groups.

VII. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the study, the following were drawn. (1) The students' performance before the intervention is below average. (2) There is a substantial increase in the student's performance in factoring quadratic trinomials after employing the sum and Product Method and the X-Box method). As shown in the study results, the post-test means scores of the learners in both groups rose from below average to average. (3) Despite the increase in the performance of both groups based on the pretest and post-test results, there is no significant difference in the post-test mean scores between the two groups. Therefore, the X-Box method is not a better intervention in developing the students' performance in factoring quadratic trinomials than other methods.

Based on the findings and conclusions, the following are recommended: (1) The educators may incorporate other methods in factoring quadratic trinomials (e.g. X-Box method) into the mathematics instruction. (2) The curriculum developers may offer training sessions and workshops for educators on the X-Box method and other practical teaching strategies in factoring quadratic trinomials. This will provide teachers with strategies to increase student engagement and learning outcomes. (3) Furthermore, they may create a system for continuous monitoring and evaluation of the interventions' effectiveness. This approach will help pinpoint areas for improvement and ensure that instructional strategies are regularly updated based on student performance data.

REFERENCES

[1] Bass, V. (2021). Do Time and Order Matter for Choice and Perceived Usefulness? An Evaluation of Multiple Strategies via Factorization of Quadratic Trinomials. https://www.proquest.com/openview/4d555819094f40534afdc74538f28b70/1?pq-origsite=gscholar&cbl=18750&diss=y

[2] Fraenkel et al. (2012). How to Design and Evaluate Research in Education - Eighth Edition. Avenue of the Americas, New York, USA: The McGraw-Hill Companies, Inc. https://saochhengpheng.wordpress.com/wp-content/uploads/2017/03/jack_fraenkel_norman_wallen_helen_hyun-how_to_design_and_evaluate_research_in_education_8th_edition_-mcgraw-hill_humanities_social_sciences_languages2011.pdf

[3] Loh, P. (2019). A Simple Proof of the Quadratic Formula. http://arxiv.org/pdf/1910.06709

[4] Mallick, N. (2012). Factoring a Quadratic Trinomial Function: A Formula for the two Parameters of the AC-Test Method. https://www.researchgate.net/publication/256018958_Factoring_a_Quadratic_Trinomial_Function_A_Formula_for_the_two_Parameters_of_the_AC-Test_Metho

[5] Mavrotheris, M. (2014). K - 12 Education: Concepts, Methodologies, Tools and Applications. Page(s): pp. 1–9. DOI: 10.4018/978-1-4666-4502-8.ch090

[6] Norton et al. (2022). Exploring the Challenges of Learning Quadratic Equations and Reflecting upon Curriculum Structure and Implementation. https://www.researchgate.net/publication/364674874_Exploring_the_challenges_of_learning_quadratic_equations_and_reflecting_upon_curriculum_structure_and_implementation

[7] Obongen et al. (2020). The Effect of Introducing the Box/Lattice Method to the Competency of Grade 9 Students of Holy Spirit National High School in Multiplying Polynomial. https://scholarzest.com/index.php/ejhea/article/download/91/88/374

[8] Refugio et al. (2022). Difficulties in Teaching Senior High School General Mathematics: Basis for Training Design. https://www.researchgate.net/publication/341158630_Difficulties_in_teaching_senior_high_school_General_Mathematics_Basis_for_training_design

[9] Skaalvik, E. (2018). Mathematics anxiety and coping strategies among middle school students: relations with students' achievement goal orientations and level of performance. https://www.researchgate.net/publication/323642280_Mathematics_anxiety_and_coping_strategies_among_middle_school_students_relations_with_students'_achievement_goal_orientations_and_level_of_performance

[10] Villanueva et al., (2022). Students' Performance in Factoring Quadratic Trinomials Through X-Box Method. https://www.researchgate.net/publication/361581355_Students'_Performance_in_Factoring_Quadratic_Trinomials_Through_X-Box_Method

[11] Voskoglou, M. (2019). Comparing Teaching Methods of Mathematics at University Level. https://www.mdpi.com/2227-7102/9/3/204

[12] Zalesny, D. (2011). In the Footsteps of Mathematics. http://inthefootstepsofmath.blogspot.com/2011/12/history-method-of-gelosia.html?m=1