

Integrating Variable to Enhance Problem-Solving Skills of Grade 7 Students in Linear Equations and Inequalities

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Abstract

This study demonstrates the powerful impact of the VARIABLE (*Versatile Application and Resourceful Integration of Activity-Based Learning Sheets Electronically*) intervention on enhancing Grade 7 students' skills in solving linear equations and inequalities. The study utilized one-shot quasi-experimental design, comparing pre-test and post-test results to determine if significant differences improved the effectiveness of the intervention. The results shows that students' mean scores skyrocketed from 14.22 in the pre-test to 37.78 in the post-test, with a significant t-value of 26.86 and a huge effect size of 5.55. This indicates a statistically significant improvement and a substantial practical impact. Students reported enjoying and engaging with the intervention which helped them build knowledge, master solving skills, and apply higher-order thinking. In conclusion, the intervention is exceptionally effective strategy for improving problem-solving competencies suggesting VARIABLE integration into teaching and creating contextualized learning materials along with supplementary teacher training to enhance student performance and learning enjoyment.

Keywords: Problem-solving, Linear equations, Linear inequalities, VARIABLE, One variable

Introduction

One of the worrisome problems in learning Mathematics that affects students who do Mathematics is having a lack of a strong foundation. This problem slows and hinders students not only at school but also in their real-life activities. The students get the logic behind it, but they do not know how or when to use this mechanic or in what mathematics problems it will be used.

Algebra and algebraic thinking have long been recognized as important to problem-solving in human society. According to research, students can perform well in advanced mathematics if they have a strong foundation in fundamental mathematics. Deeper learning occurs when students consistently transfer and develop new information through problem-solving. This pushes students to think critically and imaginatively about the subject and how it applies to real-world circumstances.

In order to build better self-efficacy, the conviction in one's own capacity to learn and perform well, and higher expectations for success in advanced mathematics, students must here understand the fundamentals of solving linear equations and inequality problems. These beliefs have the potential to predict success more accurately than measured aptitude and past performance. This is reinforced by the findings of Stankov & Le (2017), who discovered that self-beliefs influence cognitive performance as either facilitators (excellent calibration of self-efficacy and confidence) or barriers (anxiety). Connectedly, Simamora & Saragih (2019) proved that learning materials based guided- discovery learning with Batak Toba context improved students' mathematical problem-solving ability and self-efficacy significantly. Based on the results of the study, they suggested that mathematics teachers try to qualify learning materials and integrate local culture in mathematics learning. This is also connected to the research findings of Campanilla and Mendoza (2024) in which their study revealed that students excel in problem-solving in mathematics, but their errors are mainly in formulation. They need to improve their reading comprehension, conceptual knowledge, and reasoning skills. The study also found that students' attitudes towards mathematics were influenced by their sex but not their problem-solving performance.

Also, Alamian, & Moghadam, (2020) in their study disclosed that the teaching method based on Bruner's theory has been effective in addressing and reducing many misconceptions. This was also heightened by Pratama & Setyaningrum (2018) when the students who were exposed to the game-based learning within problem-solving (PS+GBL) significantly outperformed their counterparts who were exposed based on textbook within problem solving (PS+TB). The positive effects of PS+GBL were observed on both tests of numeracy and applied problems in geometry. In addition, the findings show the positive effects of PS+GBL method on lower and higher achievers. Further, Lieban, Reichenberger & Schneider (2018) found that activities that improved students' geometric vocabulary and understanding of transformations had opportunities to work collaboratively to develop a basic understanding of programming, and to creatively solve various problems that naturally emerged during the transition process. Likewise, this is true with a study conducted by Campanilla (2024) suggested that mathematics teachers utilize SIGNS (Solving Integers with Guided Notes and Simulations) in teaching operations of integers as well as encourage school administrators to collaborate with the SIGNS team for resource development, such as guided notes and simulations supported by guided inquiry-based materials contextualized according to curricular standards and intended learner performances regarding solving of integer operations.

Meanwhile, the 2018 PISA (OECD, 2019) results revealed that the Philippines scored 353 in Mathematics, 357 in Science, and 340 in Reading, all below the average of participating OECD countries. This reflected also the Regional MPS of the NAT 2018 (RO2, 2019) where learners' performance scaled at 35.34% and problem-solving registered 39.95%.

Based on the General Weighted Average (GWA) last School Year 2023-2024 of Matucay National High School, the Overall GWA of Grade 7 students towards mathematics is 84.12, which landed the lowest rank in terms of all the subject areas, indicating that mathematics has the least mastered competencies of all the essential competencies that should be mastered by grade 7 learners. This is also supported by their least-mastered competencies in the problem-solving part of the lessons, wherein their understanding of solving word problems is low, which is reflected in their examinations' item analysis. Another reason is that the students hated mathematics for a reason, and they found it boring, based on the perceptions of Grade 10 students towards mathematics last year by other grade-level researchers. That's why Campanilla (2024) had made a study about having a continuing profession on obtaining masters degree to cope up with the ideals of the new generation. Further, the study of Campanilla (2024) on the motivation of learners towards mathematics shown that they align their personal goals with learning, and their motivation is crucial for positive study habits and academic achievement, particularly in mathematics.

Also, in Matucay National High School, students recorded a 47.49 in Mathematics of the 2016-2017 NAT, where problem-solving was rated 51.51, information literacy was rated 46.35, and critical thinking was rated 44.6. Likewise, NAT 2017-2018 results showed a 38.89 rating, where problem-solving was rated 52.78, information literacy was rated 36.11, and critical thinking was rated 27.78. These NAT results have shown an effect of depletion on the mathematical abilities of learners in MNHS, which needed to provide solutions in order to strengthen the foundations and skills of students towards problem-solving. In addition, Lee and Han (2018) showed that teaching methods based on mathematical problem-posing activities had a more positive effect on students' mathematics achievement and the affective characteristics of mathematics than the teaching method that focuses on problem-solving. It investigates the frequency and types of errors, explains their causes, and provides recommendations for instructional interventions to help students improve their problem-solving skills. These challenged the researcher to develop an intervention to affect M7AL-IIj-2 Solves Problems Involving Equations and Inequalities in One Variable.

With these, the researcher made use of VARIABLE (Versatile Application and Resourceful Integration of Activity-Based Learning Sheets Electronically) in Solving Linear Equations and Linear Inequalities Among Grade 7 Students of Matucay National High School. VARIABLE is logically based on Bruner's theory which introduced exploratory learning as one of the most well-known cognitive paradigms based on constructivism. This is aimed at developing the problem-solving skills of the Grade 7 along linear equations and linear inequalities. This increases student interest and engagement with activity-based learning sheets by introducing the solving of linear equations through an interactive, dynamic environment of learning. Through technology, the students enhance their ability to solve problems better. In Sinuraya & Frisnoiry's study (2023), they discovered that the use of PBL Electronic Student Worksheets (E-LKPD) has led to significant improvements in mathematical problem-solving skills, with a rise in average performance of 34.86%. The authors further comment that these worksheets are constructed on the ADDIE model for it to be valid, practical, and effective in the classroom setting. In addition, Bocka et al. (2008) established in their research that the dynamic worksheets that contain multimedia features enable active exploration of the mathematical concepts by the students. This technique facilitates independent learning and increases the understanding through visualizations. The "I-you-we" philosophy fosters cooperative learning, where students are deeply engaged with problems in mathematics. Similarly, Green (2009) mentioned that spreadsheets have a contemporary setting for solving the equations, making algebra more interactive. They help students see and manipulate equations in a way that promotes deeper understanding of algebraic ideas. The study of Issakova (2006) also supported this by pointing out that tools such as T-algebra provide step-by-step problem-solving interactive environments, with instant feedback and support for students in learning. Electronic learning sheets and dynamic environments have greatly enhanced learning, but some educators believe that the old ways are not dead and should be used to build the fundamental skills. Balancing both approaches may yield the best educational outcomes.

VARIABLE or shorthand for *Versatile Application and Resourceful Integration of Activity-Based Learning Sheets Electronically* in Solving Linear Equations and Linear Inequalities is anchored on problem-based where complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. In addition to course material, Problem-Based Learning may help students improve their critical thinking, problem-solving, and communication skills. It can also provide opportunities for group work, finding and evaluating research materials, and life-long learning, as well as providing students with learning difficulties with the critical learning support they require to progress from initial acquisition of a math concept and skill to independent performance of the math concept and skill. Problem-Based Learning (PBL) represents an innovative approach to educating, promoting student-centered and real-life problem-solving. Research in a wide range of disciplines-from medical education through police training-has indicated some impressive possibilities for this technique, where critical thinking, cooperation, and self-directed learning tend to result. According to Shipton (2023), and Redrobán & Durán (2024), PBL is important for enhancing such critical thinking and problem solving abilities needed in the practice of profession like medicine and policing. In a study on fifth-grade students by Ardana et al. (2024), PBL significantly improved learning outcomes, with student performance rising from 40% to 94.28% after implementing the model. Successful PBL

requires clear learning objectives, teacher training, and a supportive environment as cited by Ni'mah et al. (2024). Furthermore, the approach encourages students to be active in content and thus, autonomy in the learning process, which is a factor that is highlighted in the study by Neto et al. (2024).

VARIABLE has a series of activities and worksheets that are designed electronically and arranged according to degree and level of difficulty. It is also composed of a series of puzzles and riddles in the activities to boost the interest of the students to solve problems. VARIABLE was a teacher-made teaching strategy divided into eleven parts following ONE VARIABLE steps:

1. **Overview of the sheets.** Students find what they are solving for. Students are set to work on a series of activities. Thus, students have to be motivated to go through the activities in the VARIABLE.
 - **Note important information.** Students need to ask themselves, "What information is given?". Students take note of the important details or data in the problem sets.
 - **Equation creation.** Students begin setting up the equation and answering the problem set.
 - **Valuate the sign.** Students' ingenuity will be tested based on how they go through the steps in the sessions.
 - **Ascertain your signs.** Students' creativity allows them to decide the step or formula they must implement in the problem set.
 - **Read the problem.** Students are given ample time to redo or move up to another activity.
 - **Integrate steps.** Students perform the steps in solving the problem set.
 - **Answer the question.** Students answer the general question and provide the overall findings.
 - **Bring out generalization.** Students generalize the lessons they learned in their journey and connect them to their real lives.
 - **Learn-Relearn-Unlearn.** Students presented the issues that they wanted to resolve and the thoughts they wanted to learn, relearn, or unlearn.
 - **Entail reflection.** Students creatively write their reflections.

After the students underwent ONE VARIABLE, they were to apply the knowledge and skills they acquired which led to the last part which was the ENTAIL REFLECTION part. This part includes concrete activities related to the topic. Hence, the students showed practical applications of the topic in their daily lives. Students built their critical thinking and creativity in applying the topic. Students also shared their experiences through journal writing. The most significant role of reflection is the improvement of learning in self-awareness, critical thinking, and personal development. It enables students and instructors to reflect on their experiences, which leads to more profound understanding and application of knowledge. This not only benefits individual learners but also contributes to the general educational environment. According to Flynn (2024), "reflection helps students understand where they are and where they need to improve.". Further, it motivates students to relate new knowledge learned to personal and professional domains. This was also substantiated in the study by Shaheen & Fotaris (2023), wherein these reflective practices for digital game-based learning advance critical thinking and motivation through making learning more engaging. Jeleskovic (2023) and Juma (2024) have also pointed out that teachers who reflect can be better at their teaching activity and adjust to the needs of students. Therefore, reflective practices in schools create a culture of continuous improvement.

Generally, this research aimed to enhance the problem-solving skills of Grade 7 learners in solving Linear Equations and Linear Inequalities using VARIABLE with teacher-made learning activity sheets and worksheets as supplementary materials. It assessed the mean scores of the pre-test and post-test scores of the students in the utilization of the VARIABLE. Likewise, it determined the differences between the pre-test and post-test scores of the respondents and assessed how big is the effect size of the intervention on the performance of the students.

Methods

Research Design

This study used the one-shot quasi-experimental design where the same group received the same treatment. The experiment involved one group of participants by whom the researcher administered the pre-test, and wherein the results were recorded, tabulated, and analyzed. The same group of respondents were employed with VARIABLE then post-test was administered. The scores in the pre-test and post-test of the participants were tested and compared for significant differences to determine whether the use of VARIABLE recorded an improvement or none at all.

Research Procedure

A 40-item parallel quality assured researcher-made pre-test and post-test following the Revised Bloom's Taxonomy on Cognitive Domain for the second quarter, week 9, were the sources of primary data and were compared and analyzed using the appropriate statistical treatment. The pre-test was given to the participants before the implementation of the VARIABLE. Competencies taken from the curriculum guide for Grade 7 was administered in the scheduled VARIABLE Sessions. The selected worksheets from the LRMDs portal and other teacher-related websites and teacher-made activities was utilized appropriately. After completing the sessions, a 40-item parallel post-test was administered to the same group of students.

The researcher protected the participant's right to self-determination, anonymity, and confidentiality. For this reason, the participants and their parents were provided with complete information on the nature of this study through written informed consent, which was distributed after the meeting was called upon. The data were gathered succinctly and kept confidentially, while participants or their parents were assured of their right to

withdraw at any time. The data and information provided by the participants were solely for this purpose. Letter permissions were forwarded following protocols strictly and ethically in the process by the researcher and proper dissemination followed through. Also, all sources and references were properly and correctly cited. Data gathered were treated with utmost confidentiality.

Sampling, Participants, and Locale of the Study

This study used the one-shot quasi-experimental design whereby the same group of participants received VARIABLE Approach and administered using the pre-test and post-test. The Grade 7 students were the participants of the study with a total of 50 students composed of 25 males and 25 females using random sampling. The primary data in this study were the students' scores in the pre-test and post-test to determine the effect size of VARIABLE and were compared and tested for significant differences at Matucay National High School, Allacapan North District, Matucay, Allacapan, Cagayan.

Data Analysis

This study was conducted to determine the effectiveness of VARIABLE in the problem-solving skills of Grade 7 Students along Linear Equations and Linear Inequalities. Thus, Mean, Standard Deviation, Paired Sample T-Test and Cohen's D were the statistical tools used to analyze the impact of the said intervention.

To analyze and interpret the data gathered in this study, the following statistical tools were used:

- Mean and standard deviation were utilized in analyzing the pre-test and post-test results of both groups of the study.
- Paired Sample T-Test was used in determining the significant difference between the pre-test and post-test results of the experimental and control groups.
- Cohens D was used in determining the effect size of VARIABLE in the problem-solving on linear equations of Grade 7 learners.

Results and Discussion

Respondents' Pre-Test and Post-test Scores

Table 1 shows the mean pre-test and post-test scores of the respondents before and after the utilization of the VARIABLE approach. It further shows that the pre-test scores of the respondents have a mean of 14.22 and a standard deviation of 5.54, while their post-test results have mean of 37.78 and a standard deviation of 2.32. The table reveals that there is an increase in the post-test scores of the respondents and their scores are closer to one another, exemplifying their homogeneity. This implies that the use of intervention has greatly boosted the respondents' post-test scores when compared to their pre-test results. This further implies that their exposure to VARIABLE has greatly helped in the improvement of their skills in solving linear equations which signifies that the posttest scores are more dispersed compared to the pretest score. Based from the table 1 scores, the students' post-test scores show an increase over the pretest scores. The comparison implies that the students performed better in the post-test than in the pre-test. The study of Simamora, & Siagian, (2021) pointed out that Guided-Discovery learning model with a scientific approach assisted by GeoGebra software and student attitudes in learning mathematics on the topic of Geometry improved the post-test of the participants. This was also supported by Malambo et al. (2023) that incorporating realistic mathematics education (RME) principles significantly improved student performance in systems of linear equations. An experimental group taught using these principles outperformed a control group taught conventionally, indicating the effectiveness of activity-based learning. Moreover, Bakar & Ismail (2019) and Bakar (2019) have also found in their study that incorporating metacognitive regulation within activity-based learning enhances students' mastery of mathematical concepts through self-reflection and peer interaction. Taking into account all of the findings, results pointed out that there was a considerable increase in the performance level of the participants after the implementation of the modules, learning activity sheets, and performance tasks guided by the discovery approach. This then implies that using the VARIABLE approach in the teaching and learning process can improve the skills of the students in solving linear equations and inequalities.

Table 1: Mean Pre-test and Post-test Scores of the Respondents

Tests	N	Mean (x)	Standard Deviation
Pretest	50	14.22	5.54
Posttest	50	37.78	2.32

3.2 Test of Difference between Respodnents' Pre-test and Post-test

Table 2 illustrates the test of difference between the pre-test and post-test of the repondents. The test of difference between the pre-test and post-test scores at 0.05 level of significance claimed that it is significant in favor of the post-test. This is affirmed by the probability value of 5.61E-31 which is lower than 0.05. This is further manifested by the obtained absolute value of t-test 26.864638 which is greater than the critical value of 2.01. This implies that grade 7 learners evidently performed better during the post-test through the intervention VARIABLE being employed. This corroborates to the study of Syafti (2021) which showed that the mathematics learning outcomes of students with discovery learning model are better than those taught by conventional learning and its outcomes of students with high initial abilities and students with low initial abilities with discovery learning models of learning are better than students with high initial abilities. taught by conventional learning. It is also confirmed in the study of Saminanto (2021) which showed that guided discovery methods indicated the

participants' significant difference in their ability to connect with daily life because of contextual learning. Arbain et al. (2021) have also highlighted the implementation of problem-based learning (PBL) in linear equations resulted in a notable increase in students' problem-solving abilities, with average posttest scores rising from 16.67 to 61.36, indicating a medium level of improvement. In summary, the above-mentioned findings were recapped that learners taught with self-learning materials guided by discovery learning approach and problem-based approach were found to be of improved performance compared to those who were not taught with guided and discovery learning approach and problem-based approach. These researches indicates and supports the results that utilizing the VARIABLE approach in the teaching and learning process can improve the skills of learners towards solving linear equations and inequalities.

Table 2: Test of Difference between the Pre-test and Post-test of the Respondents

Test	N	Mean(x)	Df	t-value	t-critical	P-value	Decision
Pretest	50	14.22	49	26.864638	2.01	5.61E-31	Significant
Posttest	50	37.78					

Level of Significance: **0.05**

*Data Processed by Campanilla (2024) Using SPSS

Test of Effect Size

Table 3 shows the test of effect size using Cohen's D wherein it reveals that there is 5.55 value showing a huge effect size of using the VARIABLE approach as an intervention to the performance of the grade 7 learners in solving linear equations and inequalities. This is in relation to the study conducted by Surya et. al (2020) on the development of teaching materials based on Batak Toba culture fulfills valid, practical, and effective criteria. Teaching materials can improve students' mathematical problem-solving. This is also supported by the study of Siregar & Hasratuddin (2020) which revealed that: (1) learning devices developed based on guided discovery met valid criteria based on expert judgment; (2) learning devices developed based on guided discovery met practical criteria, in terms of a) expert judgment and b) the results of observations of the learning device implementation; (3) learning devices developed based on guided discovery met effective criteria, in terms of a) the student learning completeness classically has been achieved in the trial II by 91.43% and the disseminated stage by 94.29%, b) the achievement of learning purpose has been achieved for each item, c) the learning time used does not exceed or equals the normal learning time, and d) the student responses positive to learning devices; (4) the students' mathematical reasoning ability increased with an average of N-Gain by 0.53 in the medium category; and (5) the students' self-esteem increased with an average NGain by 0.49 in the medium category. Also, research indicates that active learning methodologies, such as PBL, significantly increase student engagement. For instance, in a study of Imelda and Anzelina (2019) found that 82% of students were active participants in learning straight line equations using a PBL module. Yuliana (2023) have also found that implementing PBL has led to notable improvements in students' mathematics scores. For example, one study reported a 58.88% increase in average scores after the first cycle of PBL implementation. Likewise, Damayanti & Susiswo (2024) stated that Guided Discovery within PBL frameworks encourages students to explore and construct knowledge actively. This method has been effective in enhancing problem-solving skills in linear equations. In short, all of the findings reiterate that developed instructional materials and discovery approaches are valid and effective because they support the increasing need for motivating learners paving the way to a much higher level of achievement among the learners. Thus, utilizing the VARIABLE approach in the process of teaching and learning can greatly affect and enhance student achievement in solving linear equations and inequalities given that it was supported by a guided discovery approach and at the same time problem based approach.

Table 3: Test of Effect Size

Test	N	Mean	SD	Cohen's D value	Scale	Remarks
Pretest	50	14.22	5.54	5.55	Above 2.0 - Huge	Huge
					1.2 -1.19 - Very Large	
					0.80 - 1.19 - Large	
Posttest	50	37.78	2.32		0.50 - 0.79 - Medium	
					0.20 -0.49 - Small	
					0.01 - 0.19 - Very small	

*Data Processed by Campanilla (2024) Using SPSS

Discussion

Overall, this paper tackles the improvement of problem-solving competencies in a one-variable linear equation and linear inequality within the context of VARIABLE. In addition, it has an objective to contribute more toward improved learning and growth in learners' performance. In summary, the mean of the pre-test and post-test

scores of the learners are 14.22 and 37.78 with standard deviation of 5.54 and 2.32, respectively. Further, there is a significant difference in the pre-test and post-test scores of the students as revealed in the computed t-value of 26.864638 which is greater than the critical value of 2.01 at 0.05 level of significance. Also, with the use of Cohen's D, the effect size of using the intervention is huge as shown in the computed value of 5.55. This results demonstrate the considerable difference between using the intervention in enhancing the skills of students in solving linear equations and inequalities in using the VARIABLE approach which shows a tremendous positive effect on the students' scores rather than of traditional one. Some researches shows that interventions in teaching linear equations and inequalities have shown significant positive impacts on students' understanding and performance. These innovative methodologies, particularly those that incorporate interactive and practical tasks, enhance students' mastery of algebraic concepts, foster critical thinking, and increase motivation towards mathematics. The study of Sansyrbayeva et al. (2024) supports the claim about the students who demonstrated a deeper understanding of algebraic concepts through innovative teaching methods. Thus, an increased independence in problem-solving was noted, allowing students to analyze and interpret problem conditions effectively. Further, it was also noted that the use of interactive lessons led to heightened student engagement and interest in algebra, resulting in improved academic performance and the application of properties of equality and inequalities in teaching provided a structured approach that reinforced learning outcomes. According to Jing (2024), advanced neural techniques, such as attention-enhanced LSTMs, have been applied to educational data analysis, improving the understanding of funding trends and patterns. Therefore, advanced techniques, like recurrent neural networks, were created to solve linear equations and inequalities quickly and accurately, where the use of technology in the education process has been demonstrated. Using these methods does not only solve equations but also improves the rate and precision with which the solution to such systems can be found. Thus, these researches results supports the overall result of the intervention used in the study and provides framework in making it as an effective intervention in solving linear equations and inequalities. This concludes that VARIABLE approach is a very effective strategy to improve the competencies in linear equations and linear inequalities in one variable of the Grade 7 students. Moreover, students engaged and enjoyed learning, which was validated by their responses to the survey conducted during the implementation of the intervention. Some of the learners' comments toward the intervention were the following: a) Learners build their knowledge beyond life scenarios while answering the VARIABLE; b) Learners love the activities because they create an avenue to discover and master specific solving skills; c) Learners appreciate the different levels of difficulty in the worksheets because they lead them to apply their higher-order thinking skills and creativity in answering tough problems. As a general conclusion, learners performed better after the use of VARIABLE, and the great increase in post-test scores is credited to VARIABLE. So, VARIABLE is a very effective strategy for enhancing the problem-solving skills of Grade 7 students in linear equations and linear inequalities in one variable. Hence, teachers may maximize the utilization of the said intervention.

Conclusion

This study demonstrates the effectiveness of the VARIABLE approach in enhancing Grade 7 students' competencies in solving linear equations and linear inequalities in one variable. The significant increase in post-test scores compared to pre-test scores, along with the positive feedback from students, underscores the success of this intervention. The findings reveal that VARIABLE not only improves problem-solving skills but also engages students, making learning enjoyable and meaningful. Consequently, the VARIABLE approach is a highly effective strategy for improving mathematical competencies.

In light of these findings, it is recommended that Mathematics teachers integrate VARIABLE into their teaching practices to foster better learning outcomes. Additionally, the development of contextualized learning materials and the creation of a VARIABLE Game App could further enhance student engagement and mastery of skills. Continuous professional development for teachers and inclusion of VARIABLE in school improvement plans are also advised to sustain and expand the benefits of this intervention.

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