Strengthening Preservice Teachers Conceptual Understanding of Linear Algebra by Using the Supplementary Book Integrated with the GeoGebra and Maple Applications

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STRENGTHENING PRESERVICE TEACHERS CONCEPTUAL UNDERSTANDING OF LINEAR ALGEBRA BY USING THE SUPPLEMENTARY BOOK INTEGRATED WITH THE GEOGEBRA AND MAPLE APPLICATIONS

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ABSTRACT

Strengthening preservice teachers' understanding of the concept of Linear Algebra is a very important and necessary action. This study is a quasi-experiment. Therefore, the treatment was given to the experiment class in the form of The Supplementary Book integrated with the GeoGebra application and to the control class in the form of the Supplementary Book integrated with the Maple application. This study aims to find out the results of using the supplementary book integrated with the GeoGebra and Maple applications in strengthening the understanding of the concept of linear algebra. A sample of 50 preservice teachers from the Department of Mathematics Education at IAIN Ambon as the Experiment class and 45 preservice teachers from the Department of Mathematics Education at Darussalam University in Ambon as the control class. The research instrument consisted of pretest and posttest questions used to determine the results of strengthening the understanding of preservice teachers' linear algebra concepts and questionnaire instruments used for Intense Continuous Attitude.. The study was started by giving a pre-test, then giving treatment using a supplement book; after that, a post-test and giving a questionnaire were carried out. The average N-Gain Score for the experiment class (GeoGebra integration) was 0.80, while the control class (Maple 18 integration) was 0.78. Significance value Sig. (2-tailed) of 0.839, which indicates that there is no significant difference between the average value of the results of strengthening the ability to understand the concepts of the two classes.
Keywords: Preservice Teachers, Conceptual Understanding, Geogebra And Maple, The Supplementary Book

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PRELIMINARY

Technology in learning has the potential to support education in the current 21st century and provide opportunities for effective communication between teachers and students in a way that could not have been done before (Stehle & Peters-Burton, 2019). The use of ICTs in class has several positive aspects. This can help prospective preservice teachers learn to encourage students to investigate themselves and change qualitatively cognitive processes to solve their problems (Azmi, 2017). ICT brings many advantages to the mathematics class; ICT can increase concentration for solving low and high problems and increase student interest in learning (Das, 2019). Preservice teachers can also use ICTs to make their learning more attractive. In this case, new technological tools such as GeoGebra, Maple, Google SketchUp, and Sketch Pad, among others, have been proven to be more effective in improving and enriching the teaching and learning of mathematics by allowing students to visualize mathematical concepts (Alabdulazis, 2021; Dahal et al., 2019). Over the years, strategic technology in teaching and learning mathematics has involved students and teachers using digital and physical resources in cautious situations (Cahyono & Ludwig, 2018). This research will be one that can contribute to integrating GeoGebra and maple applications in linear algebra learning. GeoGebra and Maple, Mathematics software combine interactive geometry, algebra, statistics, and calculus to make complete applications to produce and explain mathematical ideas for elementary to university-level students (Owusu et al., 2023).

Much literature on Linear Algebra Learning Documents the inability of students to solve fundamental problems, move flexiblely between representations, use abstract theorem in concrete situations, and even speak or write linear algebra bases in a coherent algebra. Many studies reveal the importance of understanding the concept of linear algebra (Harel, 2017; Rensaa et al., 2020; Trigueros & Wawro, 2020). However, many research results revealed that both high school and undergraduate students experienced problems understanding concepts and solving linear algebra material problems, especially the linear equation system (Astutik & Purwasih, 2023; Wati et al., 2018).

Conditions similar to the previous research results are the results of observations and researchers' interviews with several preservice teachers in the Department of Mathematics Education, the Darussalam University of Ambon and IAIN Ambon, namely they tend to explain the concept of linear algebra in a set of symbols, notations, and rules without giving context or representation of the concept. For example, when they teach the concept of a linear equation system, they only provide formulas and ask for a preservice teacher to memorize formulas and do some exercises. As a result, the Preservice Teacher sometimes needs clarification about the ideas behind the concepts. In addition, explaining the system of linear equations only by using notation and symbols tends to make the Preserver Teacher lose interest and inhibit the learning of the preservice teacher, causing a low understanding of the concepts and achievements of the preservice teacher in linear algebra, especially the linear equation system (Otten et al., 2019).

Thus overcoming some of the problems of understanding the material and difficulties in linear algebra material requires the developed material (Bagley & Rabin, 2016; Rosita et al., 2019). Baiduri et al. (2020) material development was carried out to overcome the problem of Mathematical Connection Skills for Preservice Teachers, while Pratiwi (2019) developed teaching materials based on Islamic values with a scientific scheme. The development of teaching materials by Baiduri et al. (2020) and Pratiwi (2019) do not include mathematics applications. Meanwhile (Suparjo et al., 2021) developed teaching materials by including maple applications to improve the quality of learning. These previous studies differed from this study, namely the development of GeoGebra and maple integrated supplements to strengthen the understanding of linear algebra concepts. Preservice teachers need additional books to learn basic definitions, concepts and theorems in linear algebra previously developed by researchers. Therefore, the book is called a supplement book for linear algebra material. This the supplementary books differs from previous linear algebra books because it is equipped with content and solutions to deepen linear algebra concepts and supports critical thinking skills, problem-solving, creativity, innovation, innovation and mathematical literacy needed by modern society in the 21st century. According to (Selfiardy et al., 2017b) the supplementary books are additional material that can deepen readers' understanding of certain concepts. In addition, this book is further integrated with GeoGebra and Maple applications to support the deepening of linear algebra concepts. This study aims to find out the results of using the supplementary book integrated with the GeoGebra and Maple applications in strengthening the understanding of the concept of linear algebra.

METHODS

This study is a quasi-experiment. Therefore, the treatment was given to the experiment class in the form of The Supplementary Book integrated with the GeoGebra application and to the control class in the form of the Supplementary Book integrated with the Maple application. This supplementary book summarises various relevant linear algebra books, which are then integrated with the GeoGebra and Maple applications (National Research Council, 1997). The population of this study were all first-year preservice teachers at the Department of Mathematics Education at IAIN Ambon and Mathematics Education at Darussalam University. The sample of this study was 50 preservice teachers at the Department of Mathematics Education at IAIN Ambon as an experiment class, and the control class was 45 preservice teachers at the Department of

Mathematics Education at Darussalam University, Ambon, who were selected by random cluster sampling. The instruments used were tests and non-tests. The test instrument consisted of a pre-test and a post-test to obtain data on the results of strengthening the preservice teacher's understanding of linear algebra concepts after using the Supplement Books integrated with the GeoGebra and Maple applications. Data were analyzed using the concept reinforcement rubric (Wiklund-Hörnqvist et al., 2014). The non-test instrument uses a questionnaire with an ordinal scale (Sugiyono, 2016) namely: S (happy to agree) or TS (disliked to agree). The questionnaire was used to measure the preservice teacher's opinion about the Intense Attitude of Continuing to use the Supplementary Book integrated with the GeoGebra and Maple applications. The following is the research design in Table 1 below:

Table 1. Quasi-Experiment Research Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	G	O_2
Control	O_3	M	O_4

O_1: The experiment group, before being given the strengthening of preservice teachers' concepts about linear algebra using the GeoGebra Integrated Supplement Book

O2: The experiment group, after being given a strengthened understanding of preservice teachers' concepts about linear algebra using a GeoGebra integrated supplement book

O3: The control group before being given a strengthening understanding of preservice teachers' concepts about linear algebra using an integrated maple supplement book

O4: The control group, after being given a strengthened understanding of preservice teachers' concepts about linear algebra using a Maple Integrated Supplement Book

Before the data on preservice teachers' values were analyzed statistically, a normality test was performed to determine whether the data were normally distributed and what statistical test to use. Besides that, the homogeneity test is to determine whether the population variance data from the experiment and control classes are considered the same.

The homogeneity test was carried out from the O1 and O3 pretest data to determine the initial entry point and compare differences between groups before treatment. In addition, the N-Gain score test and T-Sample test were carried out for the Posttest O2 and O4 data given to test the effect of the treatment after the experiment group received strengthening of the preservice teacher's conceptual understanding of linear algebra by using the GeoGebra (G) integrated supplement book and the control group received strengthening of the concept's understanding preservice teacher on linear algebra using Maple (M) integrated supplement book.

The category of the effectiveness of the use of the supplementary books using the N Gain Score test with the following categories:

Table 2. Category The Effectiveness of the Use of the Supplementary Books

Presentation (%)	Category
$g > 0{,}7$	High-g
$0{,}3 \leq g \leq 0{,}7$	Medium-g
$g < 0{,}3$	Low-g

Source: (Hake & Reece, 1999)

Before the instrument was tested on the research sample, the instrument was first tested to determine each item's validity, reliability and sensitivity. Next, researchers conducted instrument tests on first-year pre-service teachers at the Mathematics Education Department of Ambon IAIN with 28 respondents. The test results are then analyzed and processed using Ms Office Excel so that all the tested items are valid and reliable and that the test instruments in this study are feasible to use. The following are the results of the validity, reliability and sensitivity of the item questions:

Table 3. Test Item Validity Results

	Pre-Test					Post-Test				
No. Question	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
r_{xy}	0.512	0.568	0.674	0.402	0.431	0.485	0.654	0.564	0,667	0,679
Validity	Medium	Medium	High	Medium	Medium	Medium	High	Medium	High	High

Based on the test item eligibility criteria as predetermined, each test item is categorized as valid and suitable for use in experiment research.

Table 4. Test Item Sensitivity Results

No. Soal	Pre-Test					Post-Test				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Sensitivity	0.346	0.331	0.355	0.341	0.391	0.320	0.474	0.391	0.343	0.320
Interpretation	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive

Based on the criteria (Linn & Gronlund, 2008), all test items are categorized as good and suitable for use in experiment research.

Based on the results of calculating the reliability of the test using the Alpha formula, a reliability coefficient of 0.839 was obtained. This means the reliability of the test is categorized as moderate. Based on the validity, sensitivity and reliability calculation results, the item items were declared fit for use in field tests. The data analysis technique used is the normality test, homogeneity test, Independent Samples T-Test, and two-variable correlation test. Briefly, the flowchart of this study is presented in Figure 1.

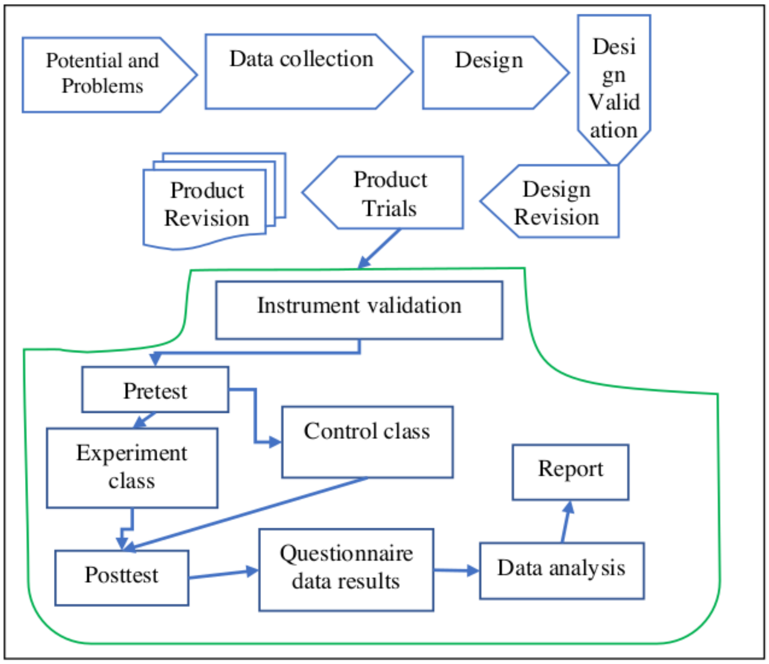


Figure 1. Research Flowchart

RESULT AND DISCUSSION

Field tests are carried out during seven meetings. In addition, the GeoGebra integrated supplement book was distributed to all preservice teachers in the experiment class, while the Maple integrated supplement book was used in the student control class.

In the experiment class, researchers explain the concepts and examples of linear equation systems and their application by integrating GeoGebra to show preservice teachers visual representation and conceptual reasoning. Then, researchers provide opportunities for preservice teachers to explore concepts taught using GeoGebra. After that, students are asked to answer the supplement book questions. The following are examples of students' test answers who experience problems in solving three-variable linear equation systems:

$$x + 2y - 3z = 4$$
$$3x - y + 5z = 2$$
$$4x + y + (a^2 - 14)z = a + 2$$

For values a?

1. The system of linear equations has no solution

2. The system of linear equations has one solution
3. The system of linear equations has an infinite solution

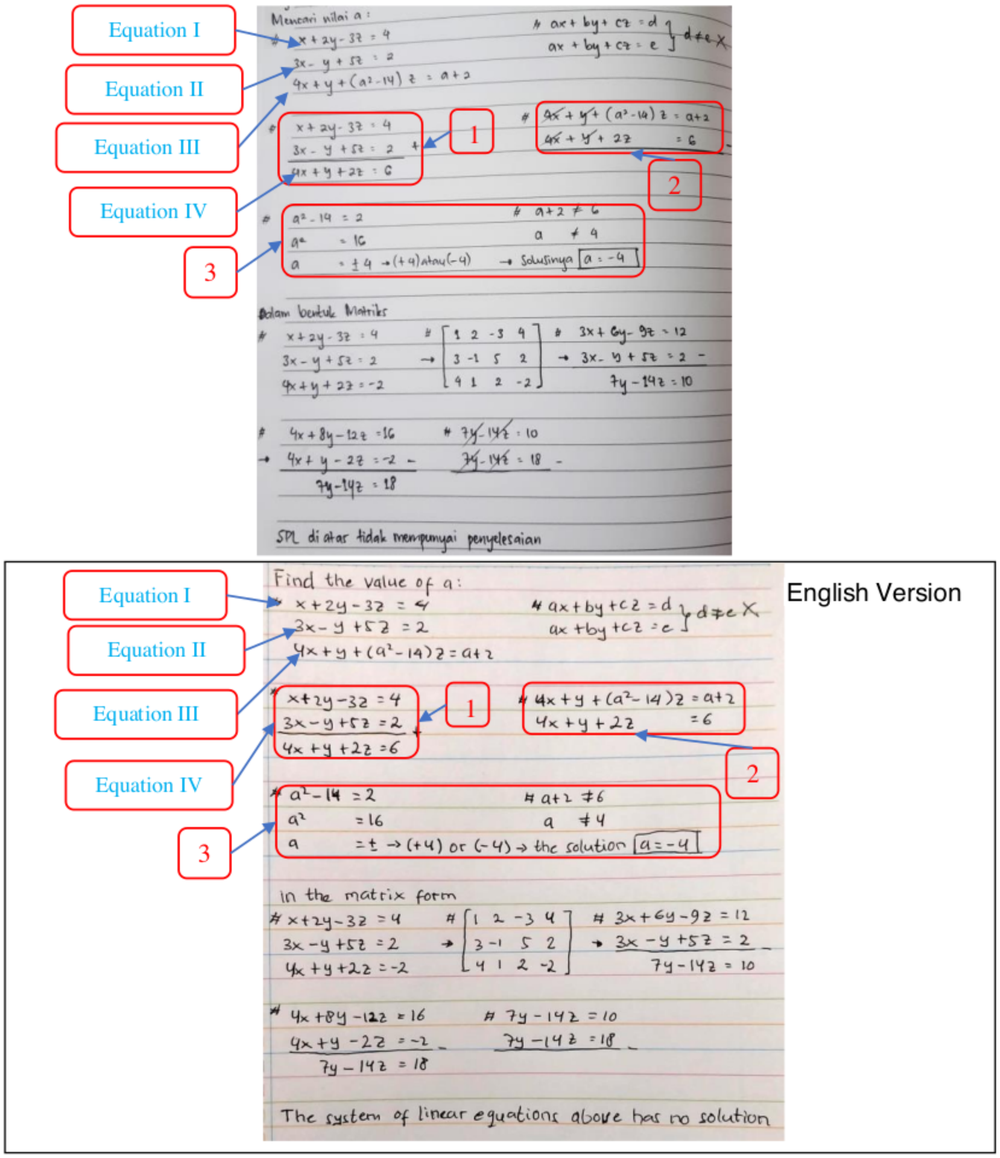


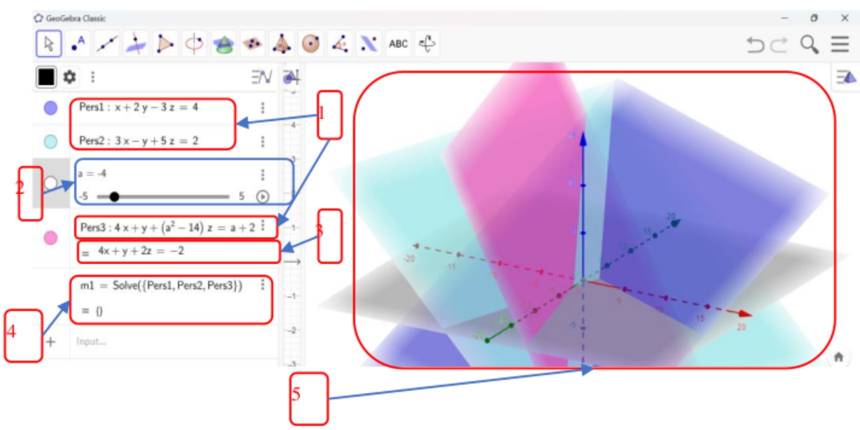
Figure 2. The Results of The Work of Students Who Experience Settlement Constraints

Figure 2 shows the obstacles experienced by students in solving the problem of the three-variable linear equation system. These obstacles can be seen from the difficulty of preservice teacher eliminating variables x, y, and z to obtain the value of a asked about the problem. Step 1 shows the preservice teacher adding equations I and II so he gets equations IV. Step 2 preservice teacher eliminates variables x and y by subtracting equations III and

IV. Based on step 2, the preservice teacher does step 3, namely stipulating that $a^2 - 14 = 2$, so that the preservice teacher gets $a = 4$ or $a = -4$ and determines that the value that meets is $a = -4$, then concludes that the system of linear equations in above has no solution.

The events experienced by students in Figure 2 correspond to several research results, which indicate that preservice teachers experience obstacles in determining the value of a variable or constant in a two/three variable system of linear equations problem (Widyastuti & Saputro, 2017). urthermore, these constraints create misconceptions among preservice teachers, as in previous studies (Fardah & Palupi, 2023; Pulungan & Suhendra, 2019). Thus, based on conditions such as the events above, some researchers suggest that preservice teachers be allowed to develop fluency in concepts (Msomi & Bansilal, 2022; Septian & Monariska, 2021).

The description of solving the problem of systems of linear equations carried out by students above shows that preservice teachers' understanding of the concept still needs to be stronger. So researchers strengthen preservice teachers' understanding of concepts by providing the Supplementary Book integrated with the GeoGebra and Maple applications. The results of solving the system problems of linear equations above, which were obtained by preservice teachers using the Supplementary Book integrated with the GeoGebra application, are as follows:



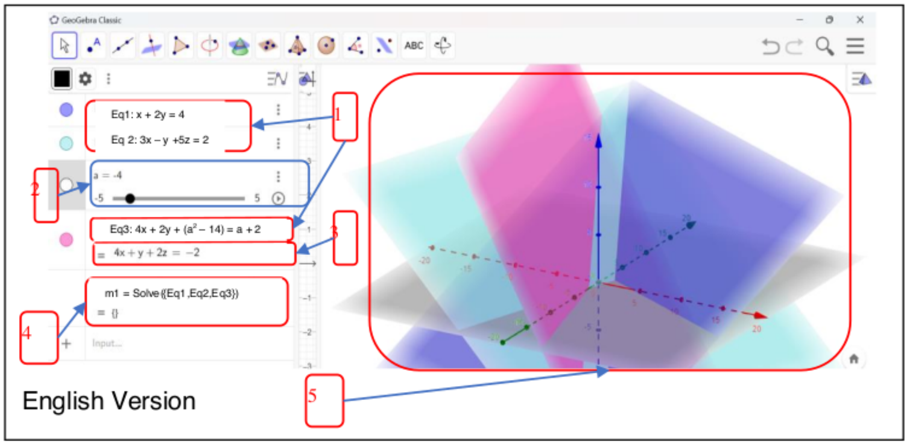


Figure 3. Processed Results of A System of Linear Equations With The Help of The Geogebra Application

Figure 3 consists of 5 points. Point 1 shows the input *a* equations in the GeoGebra application. Point 2 shows the output value obtained from the GeoGebra application after inputting the equations of Eq1, Eq2, and Eq3. In the output of this GeoGebra application, the value of *a* obtained can be displayed so that the value of a will run automatically, and Eq3 will change according to the input value of a. For example, Point 2 shows the input value *a* = *-4*, producing output point 3, namely $Eq3 := 4x + y + 2z = -2$. Point 4 shows the solution to be obtained if you want to find a solution to a system of linear equations; in this case, you have input $m1 := Solve(\{Eq1, Eq2, Eq3\})$. The output results show no solution for the system of equations if the value $a = -4$. Point 5 shows the graphical output of each equation. Thus, the preservice teachers can strengthen their understanding using the Supplementary Book integrated with the GeoGebra application.

Figure 3 above shows that using the GeoGebra application supports students' understanding of linear algebra concepts. These results are consistent with several research results (Kado, 2021; Sudihartinih & Purniati, 2019). For example, figure 2 point 2 displays the values of a so that the value of a will run automatically, and Eq3 will change according to the input value of a. For example, Point 2 shows the input value *a* = *-4*, producing output point 3, namely $Eq3 := 4x + y + 2z = -2$. Thus, the output of the GeoGebra Application supports the preservice teachers in exploring changes in constant values in Equation 3. Likewise, Figure 3 point 5 illustrates that the results of the GeoGebra application plot help preservice teachers explore the intersections between several fields so preservice teachers can know that a certain value gives one solution, many solutions, or no solution in a given system of linear equations. These events have the same character as several researchers (Mudaly & Fletcher, 2019; Tong et al., 2021). For example, Mudaly et al. (2019) found that the GeoGebra application allowed preservice teachers to successfully find the properties of straight-line graphs. Furthermore (Tong et al., 2021) found that a visual description of the continuity and discontinuity of a function at an interval with the GeoGebra application helps preservice teachers check the results of the problem through the designed function graph.

The results of solving the system of linear equations problem above, which were obtained by the subject using the Supplementary Book integrated with the Maple 18 application, are as follows:

$$\begin{bmatrix} 1 & 2 & -3 & 4 \\ 3 & -1 & 5 & 2 \\ 4 & 1 & a^2-14 & a+2 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 2 & -3 & 4 \\ 0 & -7 & 14 & -10 \\ 4 & 1 & a^2-14 & a+2 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 2 & -3 & 4 \\ 0 & -7 & 14 & -10 \\ 0 & -7 & a^2-2 & a-14 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 2 & -3 & 4 \\ 0 & 1 & -2 & \frac{10}{7} \\ 0 & -7 & a^2-2 & a-14 \end{bmatrix} \rightarrow$$

(1) (2) (3) (4)

$$\begin{bmatrix} 1 & 0 & 1 & \frac{8}{7} \\ 0 & 1 & -2 & \frac{10}{7} \\ 0 & -7 & a^2-2 & a-14 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 0 & 1 & \frac{8}{7} \\ 0 & 1 & -2 & \frac{10}{7} \\ 0 & 0 & a^2-16 & a-4 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 0 & 1 & \frac{8}{7} \\ 0 & 1 & -2 & \frac{10}{7} \\ 0 & 0 & 1 & \frac{1}{a+4} \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 0 & 0 & \frac{1}{7}\frac{8a+25}{a+4} \\ 0 & 1 & -2 & \frac{10}{7} \\ 0 & 0 & 1 & \frac{1}{a+4} \end{bmatrix} \rightarrow$$

(5) (6) (7) (8)

$$\begin{bmatrix} 1 & 0 & 0 & \frac{1}{7}\frac{8a+25}{a+4} \\ 0 & 1 & 0 & \frac{2}{7}\frac{5a+27}{a+4} \\ 0 & 0 & 1 & \frac{1}{a+4} \end{bmatrix}$$

(9)

Figure 4. Solving the Linear Equation System Using the Maple 18 Application

Figure 4 shows the results of solving the Linear Equation System using the Maple 18 Application, which consists of 9 steps. Step (1) is the result of inputting the coefficients of a system of linear equations in the Linear Algebra Gauss-Jordan Elimination Tool. Step (9) is the final result of the values of the variables x, y, z that are sought, namely $x = \frac{1}{7}\frac{8a+25}{a+4}$, $y = \frac{2}{7}\frac{5a+27}{a+4}$, and $z = \frac{1}{a+4}$. The resulting step-by-step output helps solve and deepen the problem of systems of linear equations. This agrees with (Sallah et al., 2021) utilizing the Maple Application to help deepen algebraic problems that are difficult to solve quickly. Likewise, what Bahgat (2023) has done, namely utilizing the Maple Application to get fast results in solving linear equation problems, these studies show that there is suitability that has been carried out in this study; namely the use of the Maple application helps preservice teachers deepen algebraic problems that are difficult to solve quickly.

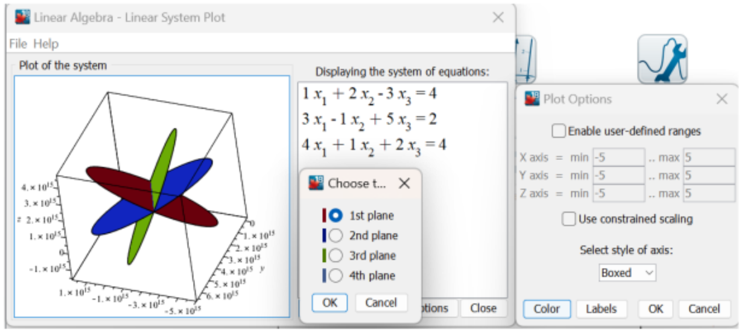


Figure 5. Graph Output Results of the Linear Equation System

Figure 5 shows the Graph Output Results of the Linear Equation System. The graphs displayed in Maple 18 help reinforce students' understanding of concepts by illustrating which areas of the graph and boundaries are given and how they look after being rotated about a particular axis. The results displayed in the Maple 18 App also confirm that the procedure given above is correct. It can be seen in the example above that a preservice teacher can solve similar questions correctly. They can also sketch graphs of a given system of linear equations. Thus, using the Supplement Book integrated with the Maple 18 application by a preservice teacher can strengthen their understanding.

Furthermore, at the end of the field test, a preservice teacher was given problems with systems of linear equations to find out their understanding after using the Supplementary Book during the learning process. The test results showed that 86% of students in the experiment class scored 81 or higher. The average score of students in the experiment class was 84.22, and the average score in the control class was 83.87.

The results of the calculation of the N-Gain score test show that the average value of the N-Gain Score for the experiment class (GeoGebra integration) is 0.80, which is included in the high level of effectiveness category. With a minimum N-Gain score of 0.40 and a maximum of 1.00, while the average N-G Score for the control class (Maple 18 integration) is 0.78, it is included in the high level of effectiveness category. Therefore, with a minimum N-Gain score of 0.40 and a maximum of 1.00, it can be concluded that the use of the Supplementary Book integrated with the GeoGebra application is effective in strengthening preservice teachers' understanding of the Linear Equation System, while the use of the Supplementary Book integrated with the Maple application is also effective in strengthening preservice teachers' understanding of System of Linear Equations.

As for the Pre-Test and Post-Test value data of preservice teachers in the experiment class and control class before being analyzed statistically, a normality test was first carried out to find out whether the data was normally distributed and to determine what statistical test to use and its homogeneity test to find out whether the population variance data from the experiment class and the control class are considered the same. The table below shows the results of the normality and homogeneity tests of the data.

Table 5. Tests of Normality

		Shapiro-Wilk		
	Class	**Statistic**	**df**	**Sig.**
Results	Pre-Test Eksperimen	.968	50	.189
	Post-Test Eksperimen	.970	50	.235
	Pre-Test Kontrol	.965	45	.197
	Post-Test Kontrol	.965	45	.197

Based on Table 5. Tests of Normality It is known that the significance/Sig. All data on the Shapiro-Wilk > 0,05, so it can be concluded that all student score data for the experiment class and control class are normally distributed.

Table 6. Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	**df1**	**df2**	**Sig.**
Results	Based on Mean	.105	1	93	.747
	Based on Median	.107	1	93	.744
	Based on Median and with adjusted df	.107	1	92.995	.744
	Based on trimmed mean	.099	1	93	.754

In the homogeneity test, because of the significance value (sig), the Based Mean is greater than 0.05. This means that the data of the two Homogeneous classes or the variants of the two classes are considered the same. To find out whether the average scores of experiment class preservice teachers were significantly different from those of control class preservice teachers, an independent t-test was used.

The hypothesis tested statistically is:

$H0$: $\mu 1 = \mu 2$ (There is no significant difference between the average score of preservice teachers' understanding of the concept of the experiment class and the control class)

Ha: $\mu 1 \neq \mu 2$ (There is a significant difference between the average scores of preservice teachers' conceptual understanding of the experiment class and the control class). The results of the Independent Samples T-Test are described below.

Table 7. Independent Samples T-Test Results

		Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Concept Understanding	Equal variances assumed	.098	.755	.204	93	.839	.333	1.632	-2.907	3.573
	Equal variances not assumed			.204	91.561	.839	.333	1.633	-2.910	3.577

Table 7 shows that the SPSS output has a significance value of 0.839, more than 0.05, so it can be concluded that there is no significant difference between the average values of the two classes. Therefore, the average score of the two classes confirms that the average score of students in the experiment class is almost the same as that of preservice teachers in the control class.

Table 8. Preservice Teachers' Intense Attitude Continues to use the Supplementary Book Integrated with the GeoGebra and Maple Applications

No	Indicators	Attitude Aspect: Description	Average (%) GeoGebra	Maple
1	Self-confidence	Self-confidence: using the Supplementary Books to measure preservice teachers' confidence in learning linear algebra. Example statement: I believe I can learn and understand linear algebra	96	96
		Math anxiety: Using the Supplementary Book to measure preservice teachers' anxiety in learning linear algebra. Example statement: Using the Supplementary Book makes me nervous	22	27
		Enjoyment of mathematics: to measure preservice teachers' pleasure in exploring the concept of linear algebra using the Supplementary Book. Example statement: I get high satisfaction from using the Supplementary Book	96	91
2	Behaviour	Intrinsic Motivation: to measure preservice teachers' intrinsic Motivation in learning algebra after using the Supplementary Book. Example statement: I plan to explore linear algebra further using the Supplementary Book	96	89
3	Cognition	Perceived Usefulness: to measure preservice teachers' perceptions of the benefits of the Supplementary Books to	96	96

No	Indicators	Attitude Aspect: Description	Average (%)	
			GeoGebra	Maple
		strengthen understanding of linear algebra. Example statement: Mathematics apps in the Supplementary Books make it easier for me to remember visualizations of linear equations		
		Average	81	80

Adaptation (Mazana et al., 2019)

Based on Table 8, out of the five indicators of intense attitude, preservice teachers' continued to use the Supplement Book integrated with the GeoGebra and Maple applications, showing a positive attitude in both classes. This can be seen from the average of the five indicators which is 81% for the experiment class and 80% for the control class. The use of the Supplementary Book integrated with the GeoGebra and Maple applications received a positive response from preservice teachers to encourage continuing students to strengthen their understanding of the concept of linear algebra.

The self-confidence indicator in Table 8 shows that the self-confidence of preservice teachers is very high. Furthermore, the preservice teachers feel the supplementary book increases their confidence in learning and understanding linear algebra. These results reinforce previous findings that the supplementary books can increase student self-confidence (Selfiardy et al., 2017a) because the supplementary books are more in-depth than textbooks and adapted to students' daily conditions (Yulia et al., 2021). Furthermore, according to Asli & Zsoldos-Marchis (2021) one of the most important things in the application of mathematics is to arouse students' interest in mathematics.

Next is mathematics anxiety. Mathematics anxiety is a condition of students' emotional response to mathematics, where students experience negative reactions to mathematical concepts and testing (Aguilar, 2021). This math anxiety creates feelings of tension, helplessness and pressure which hinder the ability to concentrate and consequently affect mathematics learning (Rada & Lucietto, 2022). However, in this study, pre-service teachers' mathematics anxiety was relatively low; most of them did not experience feelings of tension, they were empowered and did not experience inhibiting pressure because the supplementary books used had a more communicative style of language, accompanied by stories about close case studies or events. In addition, its relation to the daily life of pre-service teachers and the scope of material in the supplementary books is more in-depth than the textbooks used by other lecturers (Selfiardy et al., 2017a). Furthermore, integrating mathematical applications in the supplementary books also causes students to show positive attitudes towards mathematics and reduce their anxiety levels (Alkhateeb & Al-Duwairi, 2019; Atoyebi & Atoyebi, 2022).

According to Mazana et al. (2019), students' enjoyment of learning mathematics can affect behaviour or cognitive aspects of attitudes; students can learn mathematics because they think it is fun and interesting. This happened in this study because the supplement book integrated GeoGebra and Maple applications (Syahmarani & Nasution, 2020; Zayyadi et al., 2019). Furthermore, many studies are showing that teaching materials that have a communicative language style, are accompanied by stories about case studies or events from students' everyday lives, and more in-depth material will attract and delight students (Davis et al., 2019; Gao, 2020; Selfiardy et al., 2017a).

The emergence of preservice teachers' intrinsic motivation in this study is to explore linear algebra further because preservice teachers find benefits, exciting and fun ways to explore the concept of linear algebra with GeoGebra and Maple. This is consistent with what was found (Mazana et al., 2019), that students are intrinsically motivated to learn mathematics if they find the benefits of learning mathematics interesting. In line with that (Alkhateeb & Al-Duwairi, 2019; Hanifah, 2022), students were very motivated because they knew the benefits of learning mathematics with teaching materials based on GeoGebra or other mathematical applications.

Thus the positive response of preservice teachers to the implementation of strengthening students' understanding of mathematical concepts on an ongoing basis can be influenced by existing teaching factors and learning facilities (Moussa & Saali, 2022). Learning facilities are very important, as Law (2021) found that appropriate learning technology facilities can increase prospective teachers' effectiveness and learning experience. In the case of this study, preservice teachers feel confident they can learn and understand linear algebra, get high satisfaction from using additional books with mathematical applications, can deepen linear algebra using additional books with mathematical applications, and make it easier to remember visualization of linear equations with the support of book components supplement. Several components of this Supplementary Book include content summaries and questions in the context of Islam, maritime affairs, and culture that are integrated with the application of mathematics. Besides that, this supplement book has a communicative language style, accompanied by stories about case studies or events from students' daily lives and more in-depth material. This supports the positive response of prospective teachers, as has been found in many previous studies (Faisyal et al., 2023; Isroi et al., 2022; Nihayati et al., 2022). hus, in the case of this study, the researcher views that the sustained intensity of preservice teachers in strengthening their understanding of mathematical concepts is an important component for equipping preservice teachers to have high competitiveness in the next era.

The results above show that using the Supplementary Book integrated with the GeoGebra and Maple applications is a good idea as an innovation in the learning process. The tool can provide a clear visualization of the concepts of Linear Algebra being taught to help preservice teachers strengthen their conceptual understanding of the topic. Ultimately these results provide insights for future research and drive changes in teaching-learning practice that will enhance understanding of linear algebra concepts and subsequently, better performance in linear algebra courses.

CONCLUSION

Based on the data analysis and research discussion, the supplementary books integrated with GeoGebra and Maple applications could strengthen preservice teachers' understanding of linear algebra concepts. The ability to understand linear algebra concepts of preservice teachers' who used the supplementary book integrated with the GeoGebra application was higher than that of the preservice teachers who used the supplementary book integrated with the Maple application, although not significantly different. The continued intense attitude of preservice teachers' using the supplementary book integrated with the GeoGebra and Maple applications has a positive value.

This study was limited to samples in two mathematics education departments to strengthen understanding of the concept of linear algebra material by using Supplementary Book integrated with the GeoGebra and Maple applications so that it has limited generalization. For this reason, using a larger sample, further research is recommended to strengthen the understanding of other mathematical concepts for preservice teachers using the Supplementary Book integrated with the GeoGebra and Maple applications concepts. Besides that, further research can be reviewed from the mathematical connection side of preservice teachers in using the integrated supplement book concept GeoGebra and Maple. The next thing that is suggested is for comparative research to be done by comparing something that is equivalent.

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