The Use of Computational Mathematics Teaching Materials aided Mathematica Software in Vector Algebra Course

Abdul Baist*, Ahmad Amarullah, Prahesti Tirta Safitri, and Enawar

Universitas Muhammadiyah Tangerang, Jalan Perintis Kemerdekaan I Babakan, Cikokol, Kota Tangerang, Banten 15118, Indonesia

*abdulbaist@umt.ac.id

Abstract. This study aims to get a picture of the effect of the use of computational mathematics teaching materials aided Mathematica software on student learning outcomes. The problem commonly faced by students in vector algebra courses is the understanding of concepts in the lecture material so that it impacts on the low student learning outcomes. The method used in this study is a quasi-experimental with pretest-posttest non-equivalent control group design. The results obtained in this study are the differences in learning outcomes between groups of students who use these teaching materials and those who do not. A significant increase in student learning outcomes by an average of 5% was found after the use of computational mathematics teaching materials aided Mathematica software in the Vector Algebra course. Therefore, it can be concluded that the use of teaching materials influences student learning outcomes.

1. Introduction

Vector algebra is one of the courses in the Mathematics Education Study Program, FKIP Muhammadiyah Tangerang University. This course is a subject that must be attended by students in the Mathematics Education Study Program, FKIP Muhammadiyah Tangerang University. Vector Algebra is a course that discusses the principles of algebra that are applied to vectors.

The problem that the authors found in the Vector Algebra course was the difficulty of students in understanding the basic concepts that existed in the course so that the impact on student learning outcomes was low. It turned out that this problem was also discovered by Nurlaelah and Carina [1] where students experience errors in understanding the concept of vector space. Meanwhile Sari [2] in her study found that students find it difficult in the process of proving on linear algebra material. According with what was expressed by Britton and Henderson [3] that students have difficulty with several concepts in linear algebra. Dorier, Robert, Robinet, and Rogalski [4] revealed the causes of student difficulties in learning linear algebra not only from students but also from teachers.

Learning media is needed that can help overcome the difficulties of students in learning Vector Algebra courses. Cataloglu [5] used free open source software (FOSS) to help overcome the difficulties experienced by students in learning vector algebra. Panjaitan [6] used Matlab to study matrix algebra. Meanwhile Khair and Hariyanti [7] developed interactive e-material for Linear Algebra while Novtiar and Fitrianna [8] developed Maple-assisted learning modules.

Baist, Firmansyah, and Pamungkas [9] has made Mathematica software computational mathematics teaching material. The teaching material is designed to help students learn the material contained in the teaching material independently. One of the chapters in the teaching material is a discussion of vector algebra.

Therefore, this study aims to try to use these teaching materials in lectures of Vector Algebra. It is expected that the use of teaching materials can improve student learning outcomes in the Vector Algebra course.

2. Research Method

This research is a quasi-experimental research with pretest-posttest non-equivalent control group design. Sampling uses a purposive sampling technique with the consideration that the sample cannot be randomized properly. The sample in this study consisted of an experimental class of 24 students and a control class of 26 students in the Mathematics Education Study Program, FKIP Muhammadiyah Tangerang University in the Vector Algebra course. The research design in this study is illustrated as the following diagram [10]:

$$\begin{array}{llll} \textit{Experimental} & O_1 & X & O_2 \\ \textit{Control} & O_3 & & O_4 \end{array} \quad (1)$$

where

O_1, O_3 : pre-test

O_2, O_4 : post-test

X : Learning with specially designed teaching materials

The teaching material referred to in this study is teaching material made by Baist, Firmansyah, and Pamungkas [9]. The teaching material is a mathematics computing teaching material assisted by Mathematica software in which there is vector algebra material. The teaching material is also designed to develop students' self regulated learning.

This research will calculate the increase in student learning outcomes. Hake's gain formula [11] used to determine student learning outcomes improvement. Here is the formula:

$$g = (\%posttest - \%pretest)/(100\% - \%pretest) \quad (2)$$

3. Results and Discussion

3.1 Pretest

The following figure shows the results of the pretest for the experimental and control class.

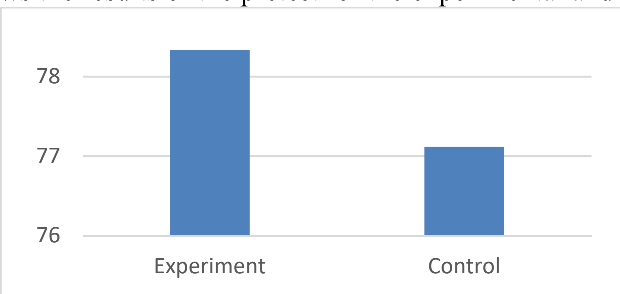

Figure 1. Mean of pretest

It can be seen from Figure 1 that the mean values of pretest between the experimental and control classes do not differ greatly. The average pretest score for the experimental class was 78.33 and the control class was 77.12. This shows that the two classes do not have differences which means that both classes depart from the same starting point.

Need further testing whether the two classes do not have significant differences. Before the test is carried out, it is necessary to know in advance the normality of data for both classes. Following are the results of normality testing for both classes.

Table 1. Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Pretest	Experiment	.857	24	.003
	Control	.853	26	.002

a. Lilliefors Significance Correction

Based on the results from Table 1, the Sig value is 0.003 for the experimental class and 0.002 for the control class both of which are smaller than 0.05 which means that the experimental class and the control class are not distributed normally. Therefore, to find out whether the two classes are not significantly different, the Mann Whitney test is used. Here are the results of the test.

Table 2. Test Statistics[a]

	Pretest
Mann-Whitney U	260.500
Wilcoxon W	611.500
Z	-1.071
Asymp. Sig. (2-tailed)	.284

a. Grouping Variable: Class

Based on the results from Table 2, the Asymp value. Sig (2-tailed) which is 0.284 is greater than 0.05 which means that the experimental class and the control class are not significantly different. Therefore, it can be said that both classes depart from the same starting point.

3.2 Postest

The following figure shows the posttest results for the experimental and control class.

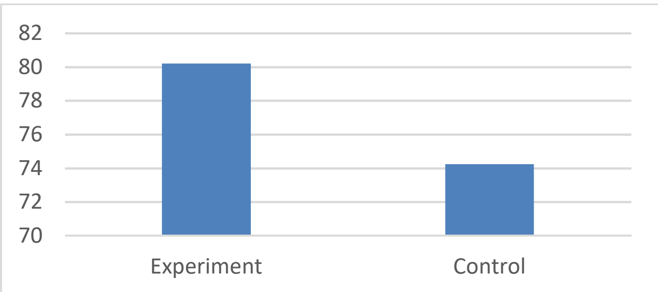

Figure 2. Mean of postest

It can be seen from Figure 2 that the mean values of posttest between the experimental and control classes differ. The average posttest score for the experimental class was 80.21 and the control class was 74.23. This shows that the two classes have differences.

Need further testing whether the two classes have significant differences. Before the test is carried out, it is necessary to know in advance the normality of data for both classes. Following are the results of normality testing for both classes.

Table 3. Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Postest	Experiment	.806	24	.000
	Control	.797	26	.000

a. Lilliefors Significance Correction

Based on the results from Table 3, the Sig value is 0,000 for the experimental class and 0,000 for the control class both of which are smaller than 0.05 which means that the experimental class and the control class are not distributed normally. Therefore, to find out whether the two classes are significantly different, the Mann Whitney test is used. Here are the results of the test.

Table 4. Test Statistics[a]

	Postest
Mann-Whitney U	81.000
Wilcoxon W	432.000
Z	-4.727
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Class

Based on the results from Table 4, the Asymp value. Sig (2-tailed) is 0.000 less than 0.05 which means that the experimental class and the control class differ significantly. Therefore, it can be said that the use of computational mathematics teaching materials aided Mathematica software influences student learning outcomes in Vector Algebra.

3.3 Gain

The following figure shows the average gain values for the experimental and control classes.

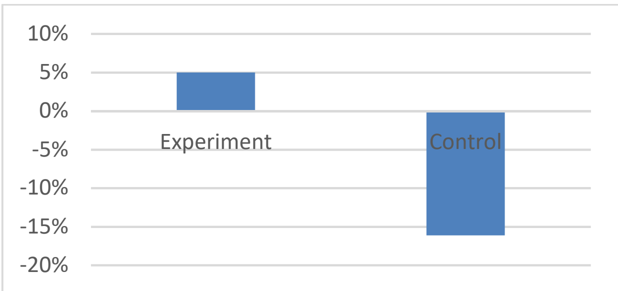

Figure 3. Mean of gain

There is a considerable difference from Figure 3 for the average gain values between the experimental and control classes. The average gain for the experimental class was 80.21 and the control class was 74.23. This shows that the two classes have differences.

Need further testing whether the two classes have significant differences. Before the test is carried out, it is necessary to know in advance the normality of data for both classes. Following are the results of normality testing for both classes.

Table 5. Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Gain	Experiment	.923	24	.067
	Control	.810	26	.000

a. Lilliefors Significance Correction

Based on the results from Table 5, the Sig value of 0.067 for the experimental class is greater than 0.05, which means the experimental class is distributed normally. While the Sig value for the control class, which is 0.000 is smaller than 0.05 which means that the control class is not distributed normally. Therefore, the Mann Whitney test was used to find out whether the two classes differed significantly. Here are the results of the test.

Table 6. Test Statistics[a]

	Gain
Mann-Whitney U	185.000
Wilcoxon W	536.000
Z	-2.534
Asymp. Sig. (2-tailed)	.011

a. Grouping Variable: Class

Based on the results from Table 6, the Asymp value. Sig (2-tailed) is 0.011 smaller than 0.05 which means that the experimental class and the control class differ significantly. Therefore, it can be said that the increase in student learning outcomes is significantly different. This shows that the use of computational mathematics teaching materials aided Mathematica software increases student learning outcomes by 5% in the Vector Algebra course.

The use of computational mathematics teaching materials aided Mathematica software significantly influences student learning outcomes in Vector Algebra course. A significant increase was also obtained by 5% for student learning outcomes in the Vector Algebra course. This is caused by teaching materials made by Baist, Firmansyah, and Pamungkas [9] designed to develop students' self regulated learning.

Using the teaching materials, students are trained to be able to learn independently. It is expected that with this students' self regulated learning can achieve academic performance, in this study better learning outcomes. As expressed by Rijal and Bachtiar [12], and Saefullah, Siahaan, and Sari [13] in their study that self regulated learning has a positive relationship with learning outcomes. Meanwhile Ningsih and Nurrahmah [14], and Aini and Taman [15] in their study stated that self regulated learning has a positive effect on learning outcomes. So as Bail, Zhang, and Tachiyama [16] said that self regulated learning has an impact on academic performance in line with what is obtained by Yusuf [17], Eshel and Kohavi [18], and Neuville, Frenay, and Bourgeois [19] in their study.

The control class in this study experienced a decrease seen from the calculation of the average gain value. This finding needs to be explored further to explore the causes of the decline in student learning outcomes.

4. Conclusions

The use of computational mathematics teaching materials aided Mathematica software influences student learning outcomes in Vector Algebra courses. A significant increase in student learning outcomes by an average of 5% was found after the use of computational mathematics teaching materials aided Mathematica software in the Vector Algebra course. As a suggestion for further research is to trace the causes of decreased student learning outcomes for the control class.

References

[1] E. Nurlaelah and E. Carnia, "PENGGUNAAN PROGRAM ISETL DALAM PEMBELAJARAN ALJABAR," Bandung, 2003.

[2] D. I. Sari, "KEEFEKTIFAN METODE SILIH TANYA MODEL KOMPETISI BIASA JENIS 1 ANTARMAHASISWA PADA MATERI RUANG VEKTOR MATAKULIAH ALJABAR LINEAR ELEMENTER SEMESTER V," *J. Ilm. Pendidik. Mat.*, vol. 5, no. 1, pp. 17–23, 2016.

[3] S. Britton and J. Henderson, "Linear algebra revisited : an attempt to understand students ' conceptual difficulties," *Int. J. Math. Educ. Sci. Technol.*, vol. 40, no. 7, pp. 963–974, 2009.

[4] J. L. Dorier, A. Robert, J. Robinet, and M. Rogalski, "On a research programme concerning the teaching and learning of linear algebra in the first-year of a French science university," *Int. J. Math. Educ. Sci. Technol.*, vol. 31, no. 1, pp. 27–35, 2000.

[5] E. Cataloglu, "OPEN SOURCE SOFTWARE IN TEACHING PHYSICS: A CASE STUDY ON VECTOR ALGEBRA AND VISUAL REPRESENTATIONS," *Turkish Online J. Educ. Technol. – TOJET*, vol. 5, no. 1, pp. 68–74, 2006.

[6] B. Panjaitan, "Designing a Learning Media using Matlab for Matrix and Its Operations," *Glob. J. Pure Appl. Math.*, vol. 12, no. 5, pp. 4431–4441, 2016.

[7] S. Khair and T. Hariyanti, "INTERACTIVE E-MATERI BASED ON DESKTOP FOR LINEAR ALGEBRA COURSE," Sumbawa, 2018.

[8] C. Novtiar and A. Y. Fitrianna, "Development of innovative teaching and learning module in linear algebra course assisted by Maple Development of innovative teaching and learning module in linear algebra course assisted by Maple," in *International Seminar on Applied Mathematics and Mathematics Education*, 2019, pp. 1–8.

[9] A. Baist, M. A. Firmansyah, and A. S. Pamungkas, "DESAIN BAHAN AJAR KOMPUTASI MATEMATIKA BERBANTUAN SOFTWARE MATHEMATICA UNTUK MENGEMBANGKAN KEMANDIRIAN BELAJAR MAHASISWA," *FIBONACCI J. Pendidik. Mat. dan Mat.*, vol. 5, no. 1, pp. 29–36, 2019.

[10] L. Cohen, L. Manion, and K. Morrison, *Research Methods in Education*, 8th ed. New York: Routledge, 2018.

[11] R. R. Hake, "Relationship of Individual Student Normalized Learning Gains in Mechanics with Gender , High-School Physics , and Pretest Scores on Mathematics and Spatial Visualization . * †," in *Physics Education Research Conference*, 2002, no. August 2002, pp. 1–14.

[12] S. Rijal and S. Bachtiar, "Hubungan antara Sikap, Kemandirian Belajar, dan Gaya Belajar dengan Hasil Belajar Kognitif Siswa," *J. Bioedukatika*, vol. 3, no. 2, pp. 15–20, 2017.

[13] I. M. S. A Saefullah, P Siahaan, "HUBUNGAN ANTARA SIKAP KEMANDIRIAN BELAJAR DAN PRESTASI BELAJAR SISWA KELAS X PADA PEMBELAJARAN FISIKA BERBASIS PORTOFOLIO," *WaPFi (Wahana Pendidik. Fis.*, vol. 1, no. 1, pp. 26–36, 2013.

[14] R. Ningsih and A. Nurrahmah, "PENGARUH KEMANDIRIAN BELAJAR DAN PERHATIAN ORANG TUA TERHADAP PRESTASI BELAJAR MATEMATIKA," *J. Form.*, vol. 6, no. 1, pp. 73–84, 2010.

[15] P. N. Aini and A. Taman, "Pengaruh Kemandirian Belajar dan Lingkungan Belajar Siswa Terhadap Prestasi Belajar Akuntansi Siswa Kelas XI IPS SMA Negeri 1 Sewon Bantul Tahun Ajaran 2010/2011," *J. Pendidik. Akunt. Indones.*, vol. 10, no. 1, pp. 48–65, 2019.

[16] F. T. Bail and G. T. Tachiyama, "Frederick T. Bail Shuqiang Zhang Gary T. Tachiyama," pp. 54–74.

[17] M. Yusuf, "The impact of self-efficacy, achievement motivation, and self-regulated learning strategies on students' academic achievement," *Procedia - Soc. Behav. Sci.*, vol. 15, pp. 2623–2626, 2011.

[18] Y. Eshel and R. Kohavi, "Perceived Classroom Control, Self-Regulated Learning Strategies, and Academic Achievement," *Educ. Psychol.*, vol. 23, no. 3, pp. 249–260, 2003.

Journal of Physics: Conference Series **1477** (2020) 022013 doi:10.1088/1742-6596/1477/2/022013

[19] S. Neuville, M. Frenay, and E. Bourgeois, "Task value, self-efficacy and goal orientations: Impact on self-regulated learning, choice and performance among university students," *Psychol. Belg.*, vol. 47, no. 1–2, pp. 95–117, 2007.