UJME 8 (2) 2019: 75-80
UNNES JOURNAL OF MATHEMATICS EDUCATION
https://journal.unnes.ac.id/sju/index.php/ujme/
ISSN: 2252-6927 (print); 2460-5840 (online)

Supporting college students' understanding of integral by using maple-integrated workbook

Herani Tri Lestiana[a,*], Dian Nataria Oktaviani[b]

[a] IAIN Syekh Nurjati, Jl. Perjuangan By Pass Sunyaragi, Cirebon 45131, Indonesia
[b] Universitas Pancasakti Tegal, Jl. Halmahera Km. 1, Tegal 52121, Indonesia

* E-mail address: h.t.lestiana@gmail.com

ARTICLEINFO

Article history:
Received 6 April 2019
Received in revised form 5 June 2019
Accepted 8 August 2019

Keywords:
Maple-integrated workbook;
Integral;
Understanding

Abstract

A factor that contributes to students' low performance in Calculus is that some teachers and lecturers tend to explain the concept of integral by using a set of symbols, notations, and rules without providing any contexts or representations of the concept. This study was aimed at supporting college students' understanding of integral by integrating Maple in the learning process using Maple-integrated workbook. This study adapted Brog and Galls' procedures which consist of collecting preliminary information, planning, developing, validation and preliminary revision, field test, and final revision. The subject of this study was college students' of Mathematics Education Department of UPS Tegal. The result showed that module developed was in a good criteria, and the conceptual understanding test showed that 82,4% students in the experimental class got a score of 71 or higher. Moreover, the average score of the experiment and control class also confirmed that the average of students' score in experiment class was significantly higher than that of students in control class.

1. Introduction

Many studies revealed that either secondary school students or undergraduate students have difficulties in learning and understanding calculus, including integral. (Orhun, 2013; Hashemi, et al., 2014; Zakaria and Salleh, 2015). Calculus contains many abstract ideas. However, some teachers and lecturers tend to explain Calculus' concepts in a set of symbols, notations, and rules without providing any contexts or representations of those concepts. For example, when they teach the concept integral, they simply give the formulas, and ask the students to memorize the formulas and do some exercises. Consequently, students get confused about the ideas behind the concepts. Moreover, explaining integral merely by using notations and symbols is likely to make students lose their interest. Those factors lead to students' low performance in Calculus (Zakaria and Salleh, 2015; Hashemi, et al., 2015).

The National Research Council defines conceptual understanding as "comprehension of mathematical concepts, operations, and relations". More specific in calculus topic, Orhun (2013) stated that "understanding calculus concepts is the ability to explore the facts, rules and concepts, and how they connect within the mathematical context".

The use of tools can be a good way to encounter some abstract topics in mathematics such as integral. Hiebert et al. (Leng, 2011) emphasized that mathematical tools are helpful for students in making connections to build their mathematical understanding. Tools, such as Computer Algebra System (CAS), can function as a bridge to construct students' understanding of abstract ideas in mathematics including integral.

Maple is one example of CAS that can provide visual representations of mathematics concepts. Many researchers showed that CAS can present abstract ideas, concepts, and proofs visually so it leads students to have a logical and an analytical thinking (Drivjers, 2002; Fuchs, 2001, Noinang et al., 2008). Moreover, Maple helps students in actively constructing their understanding of concepts and problem solving skill as it offers a step by step solution or computation (Yu, 2013).

To cite this article:
Lestiana, H. T. & Oktaviani, D. N. (2019). Supporting college students' understanding of integral by using maple-integrated workbook. *Unnes Journal of Mathematics Education*, *8*(2), 75-80. doi: 10.15294/ujme.v8i2.31971

By using Maple, students have an opportunity to explore patterns, relationships among concepts, and visual representation of those concepts. Integrating maple in the learning process and learning tools such as workbook and textbook has been proved to have a positive impact on students' understanding (Noinang et al., 2008; Zakaria and Salleh, 2015).

According to those statements, in this study integral's conceptual understanding was identified as an ability to present a visualization of a concept of integral, and to explore and apply appropriate integral's rules and operations in solving problems.

Therefore, based on those theories and findings, maple-integrated workbook was developed in this study to promote college students' understanding of calculus, particularly on the topic of Integral. To achieve that goal, this study tried to seek below question: *How is students' understanding after using Maple-integrated module?*

2. Methods

This study was a Research and Development study that is associated with experimental study. The subject of this study was college students majoring Mathematics Education in Pancasakti University Tegal.

In developing the module, Brog and Galls' steps were adapted which consist of collecting preliminary information, planning, developing, validation and preliminary revision, field test, and final revision. Firstly, important information was collected from some references and sources. The information was about the needs and problems encountered by college students and the lecturers about Integral Calculus subject, theories grounding the problems, and the materials needed for the module. From those materials, the content and the organization of the module were planned and drafted. Then, the workbook/textbook integrated with Maple for college students was developed. The textbook contains the explanation of the concept of integral together with its representations using Maple, some examples, and some problems for students to solve. Before being employed in the field test, the module was examined by six experts to figure out its validity. The result confirmed that the module is in a very good category. Thereafter, the module was applied in the teaching and learning process.

Among the steps used in this study, this article put more emphasis and detail on the result of the last phase, which was the field test.

At the end of the field test, the college students were given a set of Integral problems to figure out their understanding after using the module during the learning process. The problems were designed by referring to the indicators of conceptual understanding that have been set in this study. The problems had also been tested for its validity and reliability. The result showed that the problems were valid and reliable, and thus can be used in the field test.

3. Results & Discussions

Described below the results of each step used in this study.

3.1. Collecting preliminary information

In this phase, some students were interviewed to get some insight about the calculus class. The result of the interview showed that in the previous calculus class, students did not use any modules or handouts. In the learning process, the lecture explained the topics of calculus, and the students just wrote down what the lecture explained. Moreover, the lecture did not utilize any softwares or mathematics programs. Thus, the class was lack of an opportunity to get a good visualization and representation of calculus topics.

3.2. Planning

Based on the literature review and interview in the planning phase, the draft of the module and the validation instrument were developed. The content of the module consisted of three main topics which were arranged based on learning goals. The topics included in the module were anti-derivation and indefinite integral, definite integral, and the application of definite integral.

3.3. Developing

In this phase, the content of the module was developed in detail for each topic. Beside, the validation instrument of the module was also developed based on BSNP's (2014) indicators. The validation criteria of the module were reviewed based on its appropriateness of content, language, and presentment.

3.4. Validation and preliminary revision

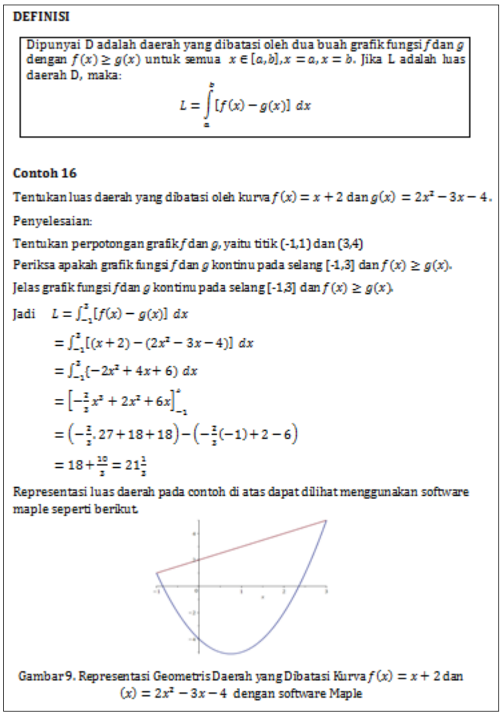
After being developed, the module and the instrument were consulted to some experts in

Calculus and its instruction. The result of the expert validation showed the average score was 3,76 out of 4. The number indicated that the module was in a good statement.

3.5. Field test and final revision

The field test was carried out for eight meetings. The module was distributed to all students in the experiment class while in the control class the students merely use a module without any combination of Maple use.

In the experiment class, the researchers explained the concept and the examples of Integral and its application by integrating Maple to show the students the visual representation and the reasoning of the concepts. Then, the researchers give the students opportunity to explore the concepts taught using Maple. Thereafter, the students were asked to solve the exercises in the module. Some examples of students' answers of the test were described below.



DEFINISI

Dipunyai D adalah daerah yang dibatasi oleh dua buah grafik fungsi f dan g dengan $f(x) \geq g(x)$ untuk semua $x \in [a,b], x = a, x = b$. Jika L adalah luas daerah D, maka:

$$L = \int_a^b [f(x) - g(x)]\ dx$$

Contoh 16

Tentukan luas daerah yang dibatasi oleh kurva $f(x) = x + 2$ dan $g(x) = 2x^2 - 3x - 4$.

Penyelesaian:

Tentukan perpotongan grafik f dan g, yaitu titik (-1,1) dan (3,4)

Periksa apakah grafik fungsi f dan g kontinu pada selang [-1,3] dan $f(x) \geq g(x)$.

Jelas grafik fungsi f dan g kontinu pada selang [-1,3] dan $f(x) \geq g(x)$.

Jadi $L = \int_{-1}^{3} [f(x) - g(x)]\ dx$

$= \int_{-1}^{3} [(x+2) - (2x^2 - 3x - 4)]\ dx$

$= \int_{-1}^{3} (-2x^2 + 4x + 6)\ dx$

$= \left[-\frac{2}{3}x^3 + 2x^2 + 6x\right]_{-1}^{3}$

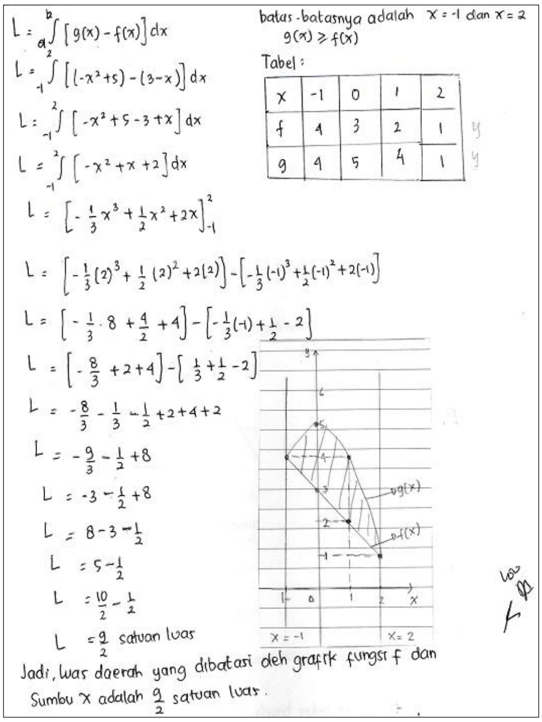
$= \left(-\frac{2}{3}.27 + 18 + 18\right) - \left(-\frac{2}{3}(-1) + 2 - 6\right)$

$= 18 + \frac{10}{3} = 21\frac{1}{3}$

Representasi luas daerah pada contoh di atas dapat dilihat menggunakan software maple seperti berikut.

Gambar 9. Representasi Geometris Daerah yang Dibatasi Kurva $f(x) = x + 2$ dan $g(x) = 2x^2 - 3x - 4$ dengan software Maple

Figure 1. Workbook preview



$L = \int_a^b [g(x) - f(x)]\ dx$

$L = \int_{-1}^{2} [(-x^2+5) - (3-x)]\ dx$

$L = \int_{-1}^{2} [-x^2 + 5 - 3 + x]\ dx$

$L = \int_{-1}^{2} [-x^2 + x + 2]\ dx$

$L = \left[-\frac{1}{3}x^3 + \frac{1}{2}x^2 + 2x\right]_{-1}^{2}$

$L = \left[-\frac{1}{3}(2)^3 + \frac{1}{2}(2)^2 + 2(2)\right] - \left[-\frac{1}{3}(-1)^3 + \frac{1}{2}(-1)^2 + 2(-1)\right]$

$L = \left[-\frac{1}{3}.8 + \frac{4}{2} + 4\right] - \left[-\frac{1}{3}(-1) + \frac{1}{2} - 2\right]$

$L = \left[-\frac{8}{3} + 2 + 4\right] - \left[\frac{1}{3} + \frac{1}{2} - 2\right]$

$L = -\frac{8}{3} - \frac{1}{3} - \frac{1}{2} + 2 + 4 + 2$

$L = -\frac{9}{3} - \frac{1}{2} + 8$

$L = -3 - \frac{1}{2} + 8$

$L = 8 - 3 - \frac{1}{2}$

$L = 5 - \frac{1}{2}$

$L = \frac{10}{2} - \frac{1}{2}$

$L = \frac{9}{2}$ satuan luas

batas-batasnya adalah $x = -1$ dan $x = 2$

$g(x) \geq f(x)$

Tabel :

x	-1	0	1	2
f	4	3	2	1
g	4	5	4	1

Jadi, luas daerah yang dibatasi oleh grafik fungsi f dan sumbu x adalah $\frac{9}{2}$ satuan luas.

Figure 2. Sample of students' answer in finding the area of given problems

The step-by-step explanation provides a clear procedure in solving the problem. In addition, the graph presented in the example gives an idea of the reasoning of f(x) ≥ g(x) and g(x) ≥ f(x). By doing so, students would be able to determine whether to use the formula of $L = \int_a^b [f(x) - g(x)]\ dx$ or $L = \int_a^b [g(x) - f(x)]\ dx$. In the answer sample above, the student tried to figure out whether f(x) ≥ g(x) or just the opposite by sketching the graph of the two functions. From the graph she found out that g(x) ≥ f(x) so she could apply the appropriate formula to find the area of given graphs and boundary.

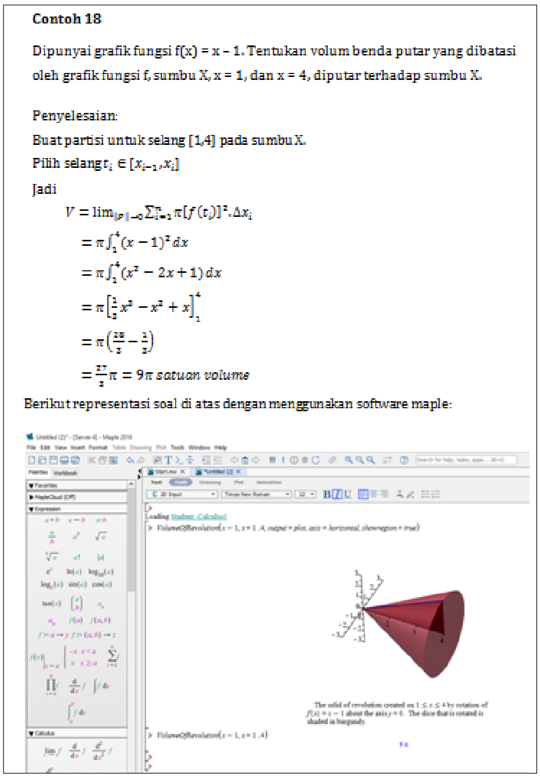


Figure 3. Workbook preview

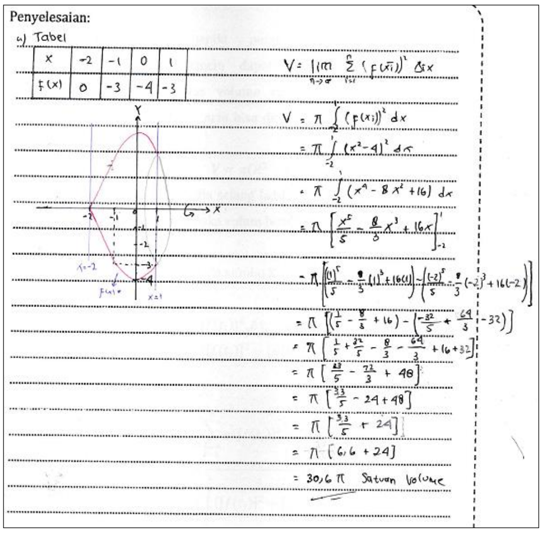


Figure 4. Sample of students' answer in finding the volume of solids of revolution

Similarly, in the topic of volume of solids of revolution by integration, clear steps of how to solve a problem are presented. Then, the graph showed in Maple strengthens the reasoning of the concept by illustrated which area of given graph and boundary, and how it looks like after being rotated on particular axis. The result displayed in the Maple software also confirmed that the procedures given above are correct. It can be seen in the example above that the student was able to solve similar problems correctly. He also could sketch the graph and the volume of solids of revolution of given function and boundary.

At the end of the field test, the students were given a set of Integral problems to figure out their understanding after using the module during the learning process.The test result showed that 82,4% students in the experiment class got a score of 71 or higher. The average of students' score in experiments class was 72,24, and the average of students' score in control class was 64,50.

Before the data of students' score was analyzed statistically, it was tested its normality to figure out whether the data was normally distributed and to determine what statistical test used, and its homogeneity to investigate if the population variance of the data was considered equal. The table below showed the result of normality and homogeneity test of the data.

Table 1. The result of normality and homogeneity test

Students' Score Data	p-value (Shapiro-Wilk Normality Test)	p-value (Test of homogeneity of variance
Experiment class	0.056	0.687
Control class	0.919	

In the normality test, as the probability value of both classes were more than 0.05, it can be concluded that the data of experiment class and control class students' score were normally distributed. Probability value of homogeneity test was also more than 0.05. It means that the variance of both classed were considered equal.

To find out whether the average of experiment class students' score was significantly different from that of control class students, independent t-test was employed.

The hypotheses that were tested statistically were:

$H_0: \mu_1 = \mu_2$ (there is no significant difference between the average conceptual understanding score of students of experiment class and that of control class)

$H_a: \mu_1 \neq \mu_2$ (there is a significant difference between the average conceptual understanding score of students of experiment class and that of control class)

The result of *Independent Samples T-Test* was described below.

Table 2. Independent Samples T-Test Result

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	.165	.687	2.187	35	.035	7.735	3.536	.556	14.914
	Equal variances not assumed			2.188	34.07	.036	7.735	3.536	.550	14.920

From the SPSS output, it can be seen that the value of significance was 0,035. As it was less than 0,05, it can be inferred that there was a significant difference between the average score of the two classes. The average score of the two classes confirmed that the average of the students' score in experiment class was significantly higher than that of students in control class.

The result above indicates that the use of a tool integrated with a module is a good idea as an innovation in the learning process. The tool can give a clear visualization of the calculus concept being taught, thus it can help students to construct their understanding of the topic.

4. Conclusion

A typical problem encountered by many students in learning calculus is the concern of abstract ideas and formulas. To understand a concept in mathematics, merely memorizing the concept is inappropriate. Students need to understand the reasoning behind the concept. Providing graphs in mathematics teaching and learning process has been confirmed to help students understanding a concept as it offers a visual reasoning of the concept. Maple can provide both, a clear step-by-step procedure and its visualization. This study revealed that the integration of Maple in the workbook can support students' understanding of Integral. The average score of students' who utilized Maple-integrated workbook was significantly higher than that of students who did not use the workbook. Moreover, students' answers on problems in the workbook showed that they could represent the problems visually and employed the correct procedure as shown in the workbook. Thus, it can be concluded that Maple-integrated workbook can help students understand the concept of integral as it provides visual representation and step-by-step procedure.

References

BSNP. 2014. *Instrumen Penilaian Buku Teks Pelajaran.* Jakarta.

Drijvers, P. (2002). Learning Mathematics in a Computer Algebra Environment: Obstacles are Opportunities. *ZDM The International Journal on Mathematics Education*, *34*(5), 221–228.

Fuchs, K. J. (2001). Computer Algebra Systems in Mathematics Education. *ZDM The International Journal on Mathematics Education*, *35*(1), 20–23.

Hashemi, N., Abu, M. S., Kashefi, H., & Rahimi, K. (2014). Undergraduate students' difficulties in conceptual understanding of derivation. *Procedia-Social and Behavioral Sciences*, *143*, 358-366.

Hashemi, N., Abu, M. S., Kashefi, H., Mokhtar, M., & Rahimi, K. (2015). Designing Learning Strategy to Improve Undergraduate Students' Problem Solving in Derivatives and Integrals: A Conceptual Framework. *Eurasia Journal of Mathematics, Science & Technology Education*, *11*(2).

Leng, E. W. (2011). Using An Advanced Graphing Calculator in the Teaching and Learning of Calculus. *International Journal of Mathematical Education in Science and Technology*, *42*, 925-938. doi: 10.1080/0020739X.2011.616914.

Noinang, S., Wiwatanapataphee, B., & Wu, Y. H. (2008). Teaching-Learning tool for integral calculus. Paper presented at the 13th Asian

Technology Conference in Mathematics, Suan Sunandha Rajabhat University, Bangkok.

Orhun, N. (2013). Assessing conceptual understanding in mathematics: Using derivative function to solve connected problems. *Turkish Online Journal of Distance Education*, *14*(3), 138-151.

Salleh, T. S. A., & Zakaria, E. (2012). Module for learning integral calculus with Maple: Lecturers' views. *TOJET: The Turkish Online Journal of Educational Technology*, *11*(3).

Yu, C. H. (2013). Evaluating some integrals with Maple. *International Journal of Computer Science and Mobile Computing*, *2*(7), 66-71

Zakaria, E., & Salleh, T. S. (2015). Using technology in learning integral calculus. *Mediterranean Journal of Social Sciences*, *6*(5), 144.