Education 4.0: Technology Integration In Calculus Course

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Abstract— This study aims to determine the effectiveness of the use of technology in calculus courses. The technology used is the integration of Mathematica software in teaching integral concepts. This study used a quasi-experimental method. The population in this study were students from one of the private colleges who took calculus courses. Two groups were selected by purposive sampling as a control group and experimental group. Each group consists of thirty students. Both groups were given pretest and posttest related to problem-solving skills. The results showed that improvement in problem-solving abilities of students who received calculus courses with Mathematica was better than students who received calculus courses without Mathematica.

Index Terms— Problem-solving skills, Mathematica, Calculus, Education 4.0

1 Introduction

ATCS [1] (Assesment and Teaching for 21st Century Skills) discusses what is meant by skills in the 21st century, namely ways of thinking, how to work, work and life skills — thinking over creativity, critical thinking, problem-solving, decision making, and learning. Therefore, everyone is required to have high-quality resilience and thinking skills in analyzing, supporting, and looking for alternatives to overcome problems that need them [2]. This component shows the importance of problem-solving skills for students.

The importance of problem-solving skills is also discussed by Hui [3], 21st-Century Partnership for Skills [1], NCTM [8], and the Ministry of National Education [6]. The problem of mathematical solving is the ability to solve mathematical problems that function non-routinely [9]. Muchlis [10] also agreed that the mathematical problem-solving ability was the ability to choose and solve nonroutine problems related to mathematics.

This capability is essential because it becomes the essential capital to overcome various things, delivered into concepts in scientific disciplines [7]. Therefore, problem-solving becomes a goal in higher education [4]. The Committee issued this at the Bachelor of Mathematics Program [5] which provides six basic recommendations for majors, programs, and all courses in mathematics. One of the recommendations summarizes all courses in mathematics to get it an activity that will help students in analytical development, problem-solving, critical thinking, and communication skills.

Calculus is one of the subjects that must be studied by mathematics students. However, there are still many students in universities who have difficulty facing courses. Although most students have studied agreed algorithms and procedures for those who are specific, understand conceptually, they often experience mistakes. The ease of these students to improve student problems still needs to be improved.

One effort that can be done to improve students' problem-solving skills in the industrial era 4.0 is learning based on information and technology. This skill is following the agreement of Aspestberger, William Barker [11] in the Undergraduate and Course Programs in Mathematical Sciences, also supporting the use of computer technology to support problem-solving and to improve understanding. Furthermore, William's computer technology will help students learn to use technology to solve problems and understand mathematical ideas.

Mathematica is one of the software (software) included in the Computer Algebra System (CAS). The use of mathematics in mathematics learning has been carried out by researchers — one of them, research conducted by Oliver Rübenkönig and Jan G. Korvink [12]. Mathematics provides unique abilities for interactive learning. Oliver Rubenkonig and Jan G. Korvink [12] used Mathematica to visualize mathematical topics including Derivatives Recovery, Finite Difference, Finite Volume, Finite Elements, Iterative Solvers, Multigrid Methods, Norm in Analysis, Partial Differential Equations, Shape Functions, dan Sparse Matrices. Based on the explanation above, the purpose of this study is "To find out, is it necessary to solve the problem of students who learn by using Mathematics higher than students who study without mathematics.

2 Method

2.1 Research Design

This study used a quasi-experimental method. In this study, a sample of two classes was taken with different learning. The first group was given a calculus course with Mathematica while the second group was given a calculus course without Mathematica. The first group as the experimental group while the second group as the control group. The design used in this study is the Pretest-Posttest Control Group Design.

2.2 Population and Samples

The population in this study were private college students who took calculus courses. Each group consists of thirty

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students. Sampling uses the Purposive Sampling method, which is a sampling technique based on consideration specifically [13]. The purpose of sampling with this technique is so that research can be carried out effectively and efficiently, especially in terms of the conditions of the research subjects and the time of the study.

3 Result and Discussion

3.1 Hypothesis Testing

Based on the table below, the posttest average of students in the experimental group was higher than the posttest average of the control group students. Besides that, it can be seen that the experimental group and the control group experienced an increase after learning activities.

TABLE 1
DESCRIPTIVE STATISTICS

Statistic	Experimental Group				Control Group			
	N	Pretest	Posttest	N-Gain	N	Pretest	Posttest	N-Gain
$\bar{X}$	30	15.50	49.93	0.05	30	11.73	12.43	0.01
SD		8.56	7.58	0.08		4.43	5.90	0.07

Based on Table 2, obtained the posttest score of the control group has the value of Asymp. Sig. (2-tailed) is less than 0.05, so H_0 is rejected while the posttest score of an experimental group has the value of Asymp. Sig. (2-tailed) more than 0.05 so H_0 is accepted. This value shows that the control group scores are not normally distributed, and the experimental group scores are normally distributed. Furthermore, after the post-test score of the control group is not normally distributed, and the experimental group is known to be normally distributed, non-parametric tests are conducted.

TABLE 2
NORMALITY TEST

	Posttest	
	Experimental Group	Control Group
N	30	30
Kolmogorov-Smirnov Z	0,08	0,20
Asymp. Sig. (2-tailed)	0,20	0,01

H_0: Posttest scores are normally distributed
H_a: Posttest scores are not normally distributed

The non-parametric test used is the Mann-Whitney test. The formulation of the hypothesis is formulated as follows:

H_0: The students that use Mathematica significantly have a lower mean posttest score or equal than students who do not use Mathematica.

H_a: The students that use Mathematica significantly have a higher mean posttest score than students who do not use Mathematica.

The following is a summary of the results of the hypothesis test.

TABLE 3
NON-PARAMETRIC TEST

Sig. (2-tailed)	*Mann-Whitney U*
0,00	184,50

Based on the table above, obtained the value of Sign (2-tailed) is less than 0.05, so H_0 is rejected. This value indicates that the students that use Mathematica significantly have a higher mean posttest score than students who do not use Mathematica

3.2 Student Activities

At first, integral learning activities assisted by Mathematica software experienced a few obstacles. Constraints that occur because the learning activities carried out by researchers are different from the learning activities that have been done before by students. According to students, computers as a supporting tool for learning activities are used during other courses. While in calculus subjects, the use of computers is limited to presenting material through Microsoft PowerPoint. The learning activities that researchers conducted using Mathematica software were based on Computer Algebra System (CAS). In addition to using Mathematica software, researchers also provide learning modules specifically designed for the program to help students learn independently.

At the first meeting, researchers introduced Mathematica software, which will be used in learning activities. The tutorial model was used in this study. Through this tutorial model, students are expected to understand more deeply the concepts that will be taught. Fig. 1. shows a student who is explaining the concept of integral area using Mathematica software.
The use of a programming language that is too much and too difficult procedure also is an obstacle in learning activities. Lecturers can spend much time explaining programming languages and procedures in using Mathematica software so that the time to explain mathematical concepts diminishes.

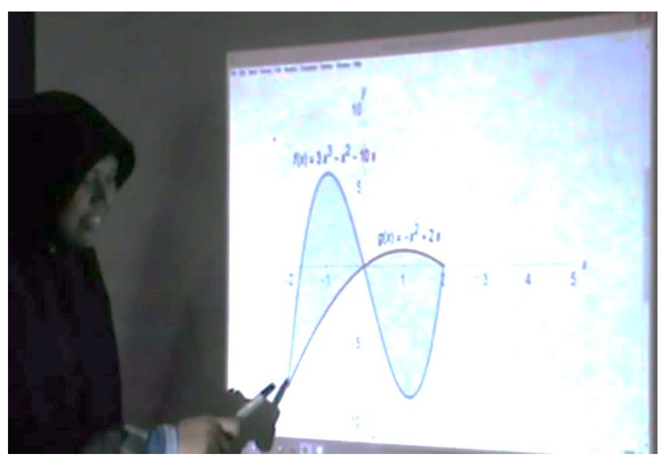

Fig. 1. Students explain the concept of the area between curves

3.3 Teaching Materials

Teaching materials used in this study were developed using the Mathematica programming language. The use of Mathematica aims to explain abstract concepts in integrals. The abstract concept is the concept of volume. The following visualizes the volume of solids concept using Mathematica.

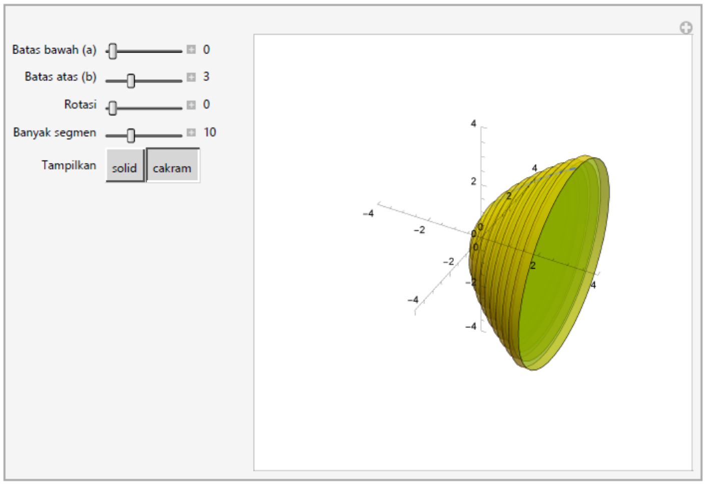

Fig. 2. Visualization of the volume by disks for rotation about the x-axis

3.4 Mathematica Programming

Mathematica was first released in 1988 by Wolfram Research, Inc. Mathematica combines symbolic manipulation, numerical mathematics, graphics, and sophisticated programming languages [14]. Because of its flexible nature, Mathematica has established itself as the preferred computer algebra system for many computer users. The following script used in Mathematica to visualize the volume by disks.

```
Manipulate[
f[x_] := 2 * x ;
volume = NIntegrate[Pi f[x]^2, {x, a, b}];
startpos[1, k_] := a + (k - 1) dx;
startpos[2, k_] := a + k * dx;
startpos[3, k_] := a + ((2 k - 1) / 2) dx;
dx = (b - a) / n;
vol = N[Sum[π * f[startpos[3, 1]]2 * dx, {1, 1, n}]];
curve = ParametricPlot3D[{x, 0, f[x]}, {x, a, b},
PlotRange → {{-4, 4}, {-4, 4}, {-4, 4}}, Boxed → False];
If[sho == 1,
solid = ParametricPlot3D[{x, f[x] * Cos[y], f[x] * Sin[y]
}, {x, a, b}, {y, 0, θ + .01},
PlotRange → {{-4, 4}, {-4, 4}, {-4, 4}}, Boxed → False],
solid = Graphics3D[
{{Yellow, Opacity[0.5], Table[Cylinder[{{a + (i - 1) dx, 0,
0}, {a + i * dx, 0, 0}},
Abs[f[startpos[3, i]]]], {i, 1, n}]}}, Boxed → False];
];
Show[{curve, solid}, AxesOrigin → {0, 0, 0}, ImageSize →
{500, 500},
PlotRange → {{-4, 4}, {-4, 4}, {-4, 4}}, Axes → True,
AxesOrigin → {0, 0, 0}],
{{a, 0, "Batas bawah (a)"}, 0, 3.9, .1, Appearance →
"Labeled", ImageSize → Tiny},
{{b, 3, "Batas atas (b)"}, 0, 10, .1, Appearance →
"Labeled", ImageSize → Tiny},
{{θ, 0, "Rotasi"}, 0, 2 π, .01,
Appearance → "Labeled", ImageSize → Tiny, Enabled →
(sho === 1)},
{{n, 10, "Banyak segmen"}, 2, 30, 1, Appearance →
"Labeled", ImageSize → Tiny},
{{sho, 2, "Tampilkan"}, {1 → "solid", 2 → "cakram"}},
TrackedSymbols :→ {n, a, b, θ, sho}, ControlPlacement →
Left]
```

4 Conclusion

The results obtained based on students' perceptions of calculus and their readiness to use knowledge in providing new perspectives in educating and studying this topic. Based on the research that has been done, it can be concluded that the problem-solving ability of students using Mathematica in a calculus course is better than students who did not use Mathematica. In other words, technology integration in calculus course is very useful in learning. Integrating computers in the learning of calculus has to be significantly considered as many research have shown a high-quality effect of this strategy on students' understanding. Thus, the new method has been deliberately in enhancing students' studying effects in calculus. For further research, larger sample size and number of research sites need to be considered in order to obtain better research results. Also, the variation of the sample used is one of the exciting aspects to be studied further in future studies. Other researchers can use more complex material than in this study. The material used should be material that is easily explained by using technology.

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