

THE DEVELOPMENT OF MAPLE-BASED CALCULUS TEACHING MATERIALS TO INCREASE ADVANCED MATHEMATICAL THINKING (AMT) STUDENTS

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ABSTRACT

The purpose of this research is to increase students AMT for succeeding their advanced lecturing especially on calculus by utilizing maple based teaching materials. Research and development is used as the methodology with 9 stages of the development of the Maple teaching materials on Calculus as follows: (1) analysis of the potential and problems, (2) data collection; (3) product design; (4) design validation; (5) design revision; (6) product tryout; (7) product revision; (8) utilization tryout; and (9) final product revision. The target of this research is the package of maple-based calculus teaching materials to increase the student's ability on AMT. The instruments used are validation sheets, form test of ATM, observation sheets, questionnaires, and interviews. The results of this research are (1) the increasment on high level of student's AMT by learning calculus with maple, and (2) The positive response from students on maple-based calculus learning.

INTRODUCTION

Advanced Mathematical Thinking (AMT) or high order thinking consists of the representational ability, abstraction, creative thinking, and argumentation. Student ability on AMT will assist their study on advanced math at universities. The AMT skill also supports the personal formation and students' intelligent, critical thinking, be a creative, empathetic with others, able to work together, confident, resilient and responsive to change. The AMT will be a part of student key success on their study and life. Furthermore, the student skills on AMT are an effort for improving human resources in Indonesia to meet the challenges of global competition, that one of them is ASEAN Economic Community (MEA).

Based on the evaluation of the exam results of Calculus, the score obtained by students for this course has not been optimal yet, it means there are still a lot of students who have score below the standard. The study evaluation of academic year 2014/2015 shows that the students scores " $B>$ " are only reached 31%, while the remaining 69% of the value of student " $B\leq$ ". This is because the average students are less able to give appropriately answer for the questions, especially the questions that are the exploratory and applicative. Based on the analysis of the pattern of student answers shows that most students are able to answer questions that are theoretical. However, for the questions that are exploratory and applicative, most students are less able to answer correctly. This shows that the students

skill are still in theoretical level, while the students skills on applying theoretical concepts and creative thinking are still less.

The situation could not be ignored, the student should realize that Calculus is a very essential, prerequisite subject for others and as a *Mata Kuliah Keahlian* (MKK). In addition, Calculus is also as a subject in other disciplines, including the Faculty of Engineering entitled "*Matematika Universitas*" or "*Matematika Teknik*". This subject also taught at the Faculty of Agriculture, Faculty of Economics, and others. Calculus is require for high order thinking in understanding it.

In the era of globalization, the rapid changing of Information and Communication Technology (ICT) drive schools, universities and institutes utilizing ICT. The implementation ICT on teaching and learning also growing rapidly. Multimedia and computer can be used to support teaching and learning process. ICT also can play its role to support teaching and learning services by using e-learning that involves students directly.

The impact of ICT utilization could be advantage and disadvantage. But based on research conducted by Maunah (2016), ICT is more has positive impact, as well as the changes of learners' social behavior. The use of ICT in teaching and learning on mathematics is essential, that ICT support and enrich student learning (NCTM, 2000). According Paradesa (2010) ICT give opportunities for teachers and students to have experience on learning process when the students are encouraged to make the mathematical estimation based on their exploitation result.

The important stage of teaching and learning process is to choose or determine appropriate instructional materials in order to help students to achieve their competencies. Lecturer is expected to develop an interesting teaching and learning materials accordance with the current situation to reach and explore the student thinking skills, especially on AMT.

Based on description above one of effort could be done to improve student AMT skill for their achievement, especially in the Calculus subject by developing teaching and learning materials on Calculus-based computer (Maple software) to teach Calculus with easy to learn and interesting.

There are 2 (two) object studies based on the background of the problems, as follows: (1) whether there is an increase of student AMT on learning Maple-based Calculus on Calculus subject? (2) how the student responses to the Maple-based learning on the Calculus subject?

METHOD

The research method used on the development of teaching and learning materials Maple-based Calculus using research and development (R&D). The product as the output is a teaching and learning materials Maple-based Calculus. According Sugiono (2010) there are ten steps on the R&D methods are shown in the following flow chart:



Figure 1 Step-by-step of R&D Method

The final stage of the development of teaching and learning materials in this study after revision based on the trial product. In details are described as follows:

1. Potential and Problems

The potential is a power or energy that has not been used optimally yet. It will have maximum benefit after use it optimally. Based on observation mostly the students of Master of Mathematics Education University of Pasundan familiar and have a skill on the use of ICT, especially computer and the Internet. 100% of students have laptop use on their learning. The readiness of the Master Program in Mathematics Education on this study is already has a program of electronic learning (e-learning) with the website address <http://s2matematika.fps.unpas.ac.id/e-learning> also has a computer lab to support the implementation of e-learning. All

the potential condition should be optimally for supporting the student's skills.

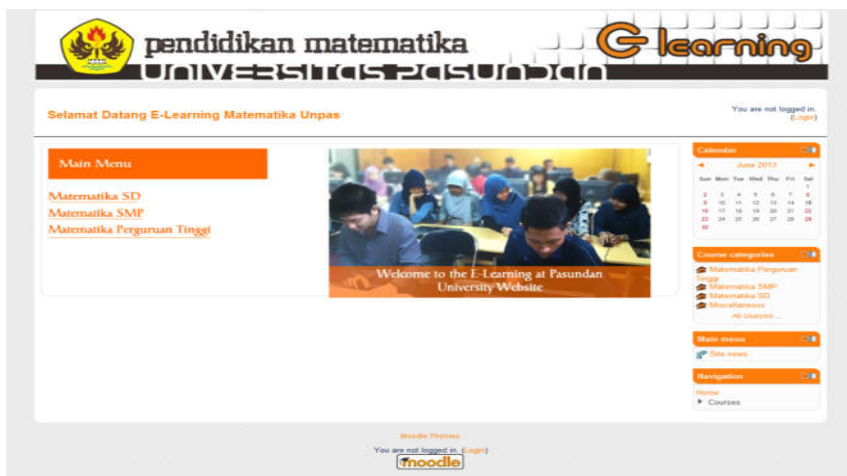


Figure 2 Interface of LMS using Moodle Platform

Besides the potential condition, there are some problems faced on (1) most of the lecturers have not optimally yet to use supporting facilities, such as e-learning facilities; (2) some of the students who active in their campus organization miss their lecturing class for following the organization activities, so make them on behind their colleagues on learning process; (3) There are several Subjects use computer lab on their teaching and learning process, such as Linear Algebra, Calculus, ICT, etc., but some of them not provide with teaching and learning materials yet

that make the students difficult to do their project by exploring the software after their tutorial class.

2. Data collection

Activities on data collection stage are to: (1) analyze the standard competence, basic competence and learning objectives; (2) analyze the teaching and learning process in the classroom; (3) analyze the student achievement; and (4) analyze the learning habits of students.

Analysis of standard competence, basic competence and learning objectives is made by making comparison between curriculums written by study program with the syllabus and SAP who the developed by the lecturer. Syllabus and SAP made by lecturers are as expected.

Analysis of the teaching and learning process carried out by interviewing the students. Learning process is mostly conducted by cooperative learning and discussion. The lecturer gives tasks and done by group. The student projects presented using PowerPoint. The ICT has already used on learning process, but only for 3 (three) softwares of SPSS (Mathematica), Cabri, and Macromedia Flash.

Analysis of the students' achievement based on their GPA. The average of GPA is 3.25. If examined more detail, the student score in Mathematic is not good since on Mathematic need student skills on exploration, reasoning, abstraction, and argumentation. It seems like with other

Subjects such as Real Analysis, Abstract Algebra, Number Systems, Advanced Calculus, and others.

Analysis of student learning process is done by interviewing 10 (ten) students. 6 (six) students are comfort learning by using computer. They stated that the computer is flexible and can use many times. 4 (four) others are like learning by face to face in classroom (classroom lecturing) since more clearer and can directly ask the questions to the lecturer.

3. Product design

Based on the analysis of potential and problems, as well as the results of data collection, Maple-based Calculus teaching materials is developed. Teaching materials are made in the form of a textbook that includes (1) the introduction (learning purposes, standard competence, basic competence, introduction to the Maple, and introduction to the Calculus); (2) the material and sample of questions (functions, limits, derivatives and integrals) equipped with the stages of completion of Calculus using Maple and exercises (teaching materials attached).

4. Design Validation

The design of teaching and learning materials validated by 2 (two) mathematician and 2 (two) media experts. The validation is for (1) materials/contents; (2) presentation materials; (3) readability and linguistic; (4) and

the completeness of component. With the assessment format as follows:

Table 2. ASSESSMENT OF TEACHING MATERIALS

Teaching Material Type :
 Title :
 Competency standards :
 Basic competencies :

No.	variable	Indicator	Evaluation result	
			Yes	No
1	Material / contents	Breadth and depth of the material in accordance with the instructional goals		
		wholeness concept		
		current		
2	presentation material	interesting		
		coherently		
		Enough examples and illustrations		
		consistent format		
3	Readability and linguistic	Variety of communicative language		
		effective sentence		
		Short words and straightforward		
		Numbering correct and consistent		
4	completeness of components	No description		
		There is a workout		
		There reinforcement		

5. Revised Design

The revise of teaching and learning materials design based on recommendations of media and content experts. The design revisions are: (1) grammar correction and punctuation; (2) numbering format; (3) simplify the sentence; and (4) adding exercises for variant difficulty level.

6. Trial Product

The revise of teaching and learning materials is try out for 10 (ten) students with select by randomly. Furthermore, student's feedbacks are given by filled the questionnaire. The questionnaire instrument as follows:

Table 3. Assessment Questionnaire in Teaching Materials

Description: 1: It is not significant, 2: Not good, 3: Moderate, 4: Good, 5: Excellent

No.	Statement	Response				
		1	2	3	4	5
1	Breadth and depth of the material					
2	Presentation material					
3	Writing					
4	The language used					
5	Exercise					
6	Strengthening component					
7	The language used					
8	Illustrations and examples					
9	Learning objectives					
10	Design of teaching materials					

The tryout results from 10 students as respondent are follows: overall average is 4.00, average per statement from (1 to 10): 4,10; 3.40; 3.90; 4.10; 4.20; 3.70; 4.40; 4.30; 3.80; 4,10. From the data the students stated that the learning and teaching materials is good.

7. Revised Product

Based on the students' tryout, overall the learning and teaching materials is good and not need to make a lot revision. The revisions are only correction for punctuation, writing, and sentences.

8. Trial Use

The final revision of teaching and learning materials are used by 6 (six) times tutorial classroom during September to October 2016. The data collection used instruments as follows: (a) AMT Pre-test and Post-test; (B) Questionnaire of students' perception for teaching and learning materials; (C) Interview guidelines; and (d) Activity observation sheet.

These instruments are as follows:

(a) AMT Test

1. Case in one country, the annual income tax levied under the following conditions. Tax-free up to an income of \$ 10,000. A tax of 10% is imposed for income in the range \$ 10,000 up to \$ 20,000. While the 15% tax imposed for income more than \$ 20,000. Define the major functions of the tax by using Maple, and then determine how much tax is levied for income \$ 14,000 and \$ 26,000.
2. A ball thrown into the air at a speed of 40 ft/sec and height (in feet) after t seconds is $y(t) = 40t - 16t^2$. By using Maple and the concept of limit, determine the speed of the ball when $t = 2$ seconds. How the direction of the ball at the time?
3. The street lights mounted on top of the mast as tall as 5 feet. A pedestrian height of 6 feet to walk away from the pole with a speed of 5 feet/sec along a straight line. How fast the tip of the shadow moves when the person is located as far as 40 feet from the pole?
4. Draw the curve $y = x - 2$ and $y^2 = 3x + 7$ and **account** the area enclosed by the curve.

(b) Questionnaire students' perception for teaching and learning materials

Table 4. Questionnaire Student's perception for teaching and learning Materials

No.	Statement	Response				
		SS	S	N	TS	STS
1	The teaching and learning materials are legibility and easy to understand (+)					
2	The teaching and learning materials made me lazy thinking (-)					
3	The teaching and learning materials meet my need (+)					
4	The language of teaching and learning materials are clear and easy to understand (+)					
5	The teaching and learning materials make math more difficult (-)					
6	Learning with The teaching and learning materials more fun than usual (+)					
7	The teaching and learning materials make uncomfortable learning (-)					
8	The teaching and learning materials are given inhibit the creativity (-)					
9	The teaching and learning materials design is not interesting (-)					
10	The teaching and learning materials are make think hard, rigorous, and creative (-)					

(c) Interview Guidelines

Interview Guidelines for Students Using Calculus Materials Based on Maple

1. What do you know about Maple?
2. What do you think about Maple-based Calculus learning?
3. Are you interest learning on Maple-based Calculus?
4. Is Maple-based Calculus learning can meet your thinking skills and improve your cognitive and affective competences?
5. Is Maple-based Calculus learning can improve your perception?
6. Do you have any difficulties in learning Maple-based Calculus?
7. What are the advantages and disadvantages of Maple-based Calculus learning?
8. What is your suggestions about the implementation of Maple-based Calculus learning?

Note:

The questions can be improved according to students feedback

(d) Observation sheet

Table 5. OBSERVATION SHEET

No.	Learning Activities	Category	
		Yes	No
1	Lecturer explains the learning activities that will be done is Maple-based Calculus		
2	Students are enthusiastic in doing the Maple-based Calculus		
3	Students pay attention to the learning and teaching materials used carefully		
4	Students learn the teaching and learning materials provided and follow the instructions		
5	Lecturer make attention and help students who are having difficulty		
6	Students do a selftest on teaching and learning materials		
7	Students are not do activities outside learning activities, such as chatting or other open textbooks		
8	Students are not having many questions about how to use teaching and learning materials		
9	Students can determine the material in accordance with the order of the material		
10	Students can answer the selftest		
11	Students make a conclusion of learning and teaching materials		
12	Lecturer discusses the selftest		

Source: Sudirman (1986) and Wahyudi (2012)

RESULTS AND DISCUSSION

Result

1. Results pretest and posttest

Descriptive analysis is used for data and information from Pre-test and Post-test to find out the students' competence on AMT skills. The descriptive analysis using SPSS version 17 as follows:

Table 6
Descriptive Analysis Data Pre-test and Post-test

	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Pre-test	33	0	11	177	5.36	2.316	5.364
Post-test	33	29	39	1174	35.58	2.222	4.939
Valid N (listwise)	33						

Table 6 showed that pre-test and post-test have a big different range, the increase (gain) it is 30.22. From pre-test and post-test average normalized using Gain formula (Hake,1999), namely "g".

$$g = \frac{\text{Score (Posttest - Pretest)}}{\text{Score (Maximum - Pretest)}}$$

Table 7
Gain Criteria: Normalized

g (Gain Normalized)	Interpretation
$g > 0,7$	High
$0,3 < g \leq 0,7$	Midle
$g \leq 0,3$	Low

Gain Score normalized = $(35.58 - 5.36) / (40 - 5.36)$
= 0.87. Based on the Gain criteria the normalized improve at the high category.

2. Questionnaire results

Table 8. Results of attitude questionnaire

No.	Statement	Response					Sum	% Of each item	Average%
		SS	S	N	TS	STS			
1	The teaching and learning materials are legibility and easy to understand (+)	20	92	18	0	0	130	78.79	75.70
2	The teaching and learning materials made me lazy thinking (-)	0	2	30	80	10	122	73.94	

No.	Statement	Response					Sum	% Of each item	Average%
		SS	S	N	TS	STS			
3	The teaching and learning materials meet my need (+)	15	44	51	2	1	113	68.48	
4	The language of teaching and learning materials are clear and easy to understand (+)	25	76	21	4	0	126	76.36	
5	The teaching and learning materials make math more difficult (-)	0	2	18	88	20	128	77.58	
6	Learning with The teaching and learning materials more fun than usual (+)	40	68	18	4	0	130	78.79	
7	The teaching and learning materials make	0	4	6	100	20	130	78.79	

No.	Statement	Response					Sum	% Of each item	Average%
		SS	S	N	TS	STS			
	uncomfortable learning (-)								
8	The teaching and learning materials are given inhibit the creativity (-)	1	4	24	84	5	118	71.52	
9	The teaching and learning materials design is not interesting (-)	1	4	39	68	0	112	67.88	
10	The teaching and learning materials are make think hard, rigorous, and creative (-)	50	84	6	0	0	140	84.85	

The total average was 75.70% higher than the neutral (58.93%). It means that overall student have positive response to teaching and learning materials of Maple-based calculus.

3. Observations

From the observation, the 12 (twelve) learning activities has been done according to observation sheet.

4. Interview result

Interviews conducted with 5 (five) students as respondent who used Maple-based Calculus teaching and learning materials. The results of interview as follow:

Students 1: Familiar with Maple and its functions. He recommended Maple very helpful as a tool to answer Mathematics quizzes also like in Calculus. He comfort to use Maple because easy for calculating and drawing, but on the other hand, Maple as easy use tool made the students on low order thinking, less critical, and not creative.

Student 2: Able to use Maple. He stated that learning Calculus using Maple is better than work on manually. He happy learning Calculus using Maple. He said that learning Calculus using Maple teaching and learning material make the students on higher order thinking and improve their cognitive and affective. Calculus learning by using Maple can improve student' insight and need a lot of reading references.

Student 3: Maple as problem solving software on mathematics. He agreed that Maple-based Calculus learning is good to help students for answering mathematic test even the difficult one. He little bit not enjoyed on learning using Maple when should remember the syntaxes command. Learning Calculus could improve students' cognitive and affective abilities and their insight. He has no difficulties to use Maple. He also said that Maple is easy to use to answer the mathematics tests but the other hand, Maple also made student on low order thinking to finish the mathematic tests.

Student 4: The student stated as follows: 1) Maple is a useful tool for calculating mathematical operations as well as for geometric sketch; 2) Helpfully, because Maple make easier working by computer inline with mastery a concept; 3) Fun learning, because Maple is fun tool when start to use it; 4) Meet the competence of cognitive but it's not sure for affective; 5) Surely, because each application has its advantages and disadvantages; 6) Yes, because just one month using Maple, 7) The advantages of Maple are computing speed and accuracy of image. But the other side, the language and page view of Maple sometimes error; 8) Maple instructional materials, but not as a primary, only a toolkit to facilitate the computation and graphs sketch. The understanding of the concept is the primary.

Student 5 Answer: 1) Maple is a mathematics tool enriched by symbols and mathematical formulas. Like matrix, exponent, integral, geometry, and others; (2) Maple is supporting tool on teaching since symbols and images on mathematics could be presented quickly; (3) Happy; (4) Yes, because the motivation learning with Maple made the continuing tryout, exploring and applying the formula into learning to increase the cognitive and affective; (5) yes, because motivated to continue learning; (6) Yes, sometimes when input data mistaken, program will error and symbols not view well; (7) Advantages: easy on typing symbols and calculate the mathematical formulas, but it's need extra accuracy in the process; (8) Maple as an alternative and innovation teaching and learning materials of mathematics.

Discussion

Based on result of the research that described previously stated the enhancement of student skills on AMT after learning Calculus using Maple-based teaching and learning materials. It can show by the mean of normally gain score on high level.

According Chaeruman (2004) the integration of ICT into teaching and learning has 3 (three) objectives, one of them is to build a "knowledge-based society habits" such as problem-solving skills, communication skills, searching skills, information management change to new knowledge and communicate it. Computer provides some tools to assist students to enhance

their skills on presentation (using images, graphics, etc.), abstraction (using symbols and equations on Microsoft Word), problem solving (using Maple, GeoGebra, Cabri, etc.).

From the data analysis of student attitude scale questionnaire, the students' feedback of on learning calculus using Maple teaching and learning materials is positive. It's cause Maple as a new learning program motivate the students learning with computer. The data showed that the percentage of each item statement higher than the average of neutral percentage. The item with highest score is statement is No. 10 (The teaching and learning materials are make think hard, rigorous, and creative because if do any mistaken, it would be an error and the input will not appear). While the smallest score is No. 9 (the teaching and learning materials design is not interesting). Design of teaching teaching and learning materials is not too much variation (not a lot of pictures or animations) since the instructional materials for adult learners.

Observation result showed that all the stages of teaching and learning materials based on SAP developed by a lecturer, starting by providing apperception, explaining the learning objectives and learning activities up to conclude the instructional materials. The role of the lectures in Maple-based Calculus learning is as the facilitator to assist students learning on Maple-based Calculus.

Student activities also implemented based on learning design. Independently, they participate on learning follow the

lecturer's instruction as follow: learning instructional materials, doing the exercises, and make concluding instructional materials. They really seemed enthusiastic following the learning activities since the mathematics learning using computer is a new learning experience for them. This can be seen from their learning habits, they prefer asking for the utilization of technical computer than instructional materials.

The study also indicated the Maple as instructional materials help students who are busy with their ekstrakurikuler activities or working or family program; they still could follow the learning activities like their colleagues at different place or time. As weel as the lecturer with similar problems on distance and learning time, they still can deliver the learning activities.

From interview stated that students were familiar with Maple and its functions. They stated Maple as a tool that can be utilized for answering the mathematical tests both of the easy and difficult one. 4 (four) from 5 (five) students said they enjoy learning Calculus using Maple. 1 (one) student not feel happy since too difficult to remember the syntax of the commands.

4 (four) students claimed that learning Calculus using Maple can enhance thinking skills and improve the cognitive as well as affective. They did practical activities by tryout, exploring, and applying the mathematics formula to improve their cognitive and skills. But 1 (one) student stated that Maple made the students on low order thinking, less critical, and not creative.

They also argue that Calculus using Maple instruction materials can expand their insight. To improve Maple skill is need to read some references and keep the learning motivation. There were 3 (three) students difficult to use Maple, since the learning Calculus using Maple is the first time for them. The error processing when input data make symbol is not appear.

The advantages of Maple are practical, answering a matter of difficult math, quick computation, and accurate image display. The other hand, the Maple make students low motivation, language and images error many time, and need an extra accuracy in the process. They adviced that Maple could be a par as instructional materials, but not as a primary, only a toolkit to facilitate the computation and graphs sketch. The understanding of the concept is the primary.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the analysis, research and discussion presented in the previous chapter, can be summarized as follows: (1) the enhancement of students' AMT who learning Calculus with Maple at a high level; (2) the student response to the Maple-based Calculus learning is positive.

Suggestion

Based on the conclusions and findings of the study, the researchers suggest the following: (1) Maple instructional materials as an alternative instructional materials use for specific mathematic such as Calculus and Linier Algebra to improve the students skills on AMT; (2) The development of Maple instructional materials advise to examine more deeply at another education; and (3) Need to conduct indepth study of the impacts of Maple instructional materials for the enhancement of AMT and review which AMT aspect is more dominant.

REFERENCES

- Hake, R. R. (1999). Interactive Engagement Versus Traditional Method: A Six Thousand Student Survey of Mechanics Test Data for Introductory Physics Course. *American Journal Physics*. 66. 64-74.
- Maunah, B. (2016). Dampak Regulasi di Bidang TIK terhadap Perubahan Perilaku Sosial Siswa Di Sekolah Menengah Kejuruan. *Cakrawala Pendidikan*. Th. XXXV, No. 2, Hal. 176-186.
- Paradesa, R., Zulkardi., Darmawijoyo. (2010). Bahan Ajar Kalkulus 2 Menggunakan Macromedia Flash dan Maple di STKIP PGRI Lubuklinggau. *Jurnal Pendidikan Indonesia*, Volume 4. No. 1, Juni 2010. Hal. 96-109.
<https://www.scribd.com/doc/262004890/7-Retni-Paradesa-95-109-pengembangan-bahan-ajar-pdf>
- Sudirman, A. (1986). *Interaksi dan Motivasi dalam Belajar Mengajar*. Jakarta: Grafindo Persada.
<http://documents.tips/documents/kisi-kisi-lembar-observasi-siswa-dan-guru.html#>
- Sugiyono. (2010). *Metode Penelitian Kuantitatif Kualitatif & AND*. Bandung: Alfa Beta.

Wahyudi. (2012). Pengembangan Bahan Ajar Elektronik Multimedia dengan Macromedia Flash 8.0 untuk Mahasiswa S1 PGSD UKSW. *Satya Widya*. Vol. 28, Hal. 55-72