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On the implementation of e-learning with *mathlet* GeoGebra in Analytic Geometry course to improve students' engagement and achievement

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Abstract. This study has been carried out to investigate the effect of the implementation e-learning with GeoGebra *mathlet* accompanied by its assessments to improve students' engagement and achievement. The problems of the study arose from our experiences that students' engagement during the course of Analytic Geometry course were very low. Because of that, an e-learning with GeoGebra *mathlet* complete with its assessments was set up using IMathAS, software especially developed for mathematics or mathematics related course. The choose of IMathAS was due to its capability to display mathematical notations, to randomize items order as well as items data, and especially to display explorative *mathlets*. After setting up the e-learning, a classroom action research was then carried out to investigate whether or not the implementation of this kind of e-learning was capable in improving students' engagement and achievement. Results showed that the implementation of this kind of e-learning was indeed capable of improving students engagements and achievement. This was clear from the progress they made during the learning process as evidenced by data obtained and its analysis.

1. Introduction

Analytic geometry is one course that usually taught in Mathematics Teacher Education and especially at the Department of Mathematics Education, Ganesha University of Education. This course is a *harmonious marriage* between Geometry and Algebra and it is a very good example to show to students that various mathematical concepts are in fact interconnected. This course is offered to students in semester III of Department of Mathematics Education, Ganesha University of Education and it is a continuation of high school mathematics subject. But, contradictive for being a continuation of high school mathematics, it is surprising that this course causes troubles to many students. This is reflected on the following table of students' achievement.

Table 1: Students achievement on Analytic Geometry on Academic year 2011/2012.

Class	Pass	Not pass	Total
3A	22	33	55
3B	17	22	39
3C	8	32	40



As a lecturer of this course for some years, various methods have been done to increase students engagement, namely (1) copying the textbook used, (2) involving students during lecture, by asking them to solve problems written on the book, and (3) asking students to present their answer to the board. However, as we mentioned earlier, students' achievement on this course is still far from our expectation. Based on our crude observation, it seems that students' engagement in this course is very low. If they are asked to do the problems on the book, then most of them are just wait and see their smart friend to come to the board, if the problems are used as a homework, then their answer will be uniform, indicating that only some of them are really do the work. Problems that appear on the book that has been copied is not interesting enough to attract students engagement.

Based on this finding, some innovative learning approaches were done to increase students' engagement. However, treatments being tried were failed to increase students engagement because there is no effort done to monitor students participation and then to value their participation, for example by considering this participations in determining their final marks. Solving the aforementioned problems will require much time, and conventional approach will not be able to overcome them. In academic year of 2015/2016, a new innovative approach have been devised to overcome this problems of engagement, that is by implementing an e-learning to students of semester III of Department of Mathematics Education, Ganesha University of Education. The e-learning was populated with (i) text material about Analytic Geometry, (ii) learning media (*mathlet*), and of course (iii) test that should be solved by students which is accompanied by feedback and grades that students achieve after doing the problems.

The e-learning have been built using a free open source software IMathAS [9]. The use of IMathAS was based on its capability to display mathematical symbols, graphics, and explorative GeoGebra *mathlets*, which is a very important tool to make students engage.

So, the research was aimed at (i) building e-learning for Analytic Geometry, (ii) increasing students' engagement, and (iii) investigating the effect of the e-learning to students achievement.

2. The importance of explorative *mathlet* in learning mathematics

Learning mathematics is learning about abstract ideas, their structure and their concepts inter-relationships. Since 'creatures' studied in mathematics are mostly abstract, then students, firstly need to be acquainted with them, study their behavior, and finally try to reconstruct them in their own way. "*Knowledge must be constructed by learners; it cannot be supplied by teachers. We all responsible for our own learning; no one can learn for us.*" [6]. Thus, students have to engage actively in the process of understanding concepts being learnt. According to Ausubel [7], even college students, during their preliminary steps in understanding some mathematical concepts will use a concrete approach, manipulate and explore it, before finally understand it abstractly. Indonesia Department of Education long ago have endorsed this approach in learning mathematics, by saying that mathematics can be defined as an activity of searching and discovering regularity and pattern, whether in number, geometry, or algebra. So, the learning of mathematics should be realized by: (1) Giving students opportunity to discover pattern and relationship, (2) giving students opportunity to explore and experiment, (3) encourage students to discover order, difference, comparison, (4) encourage students to draw conclusion, and (5) helping students in finding and understanding relationship among various concepts. [4].

The problem we then face is, how to make students, especially college students, to experiment or to explore a mathematical concept in order to understand it. This is not an easy task. To explore the concepts of addition, subtraction, or multiplication in elementary school, concrete materials can be used. But how to explore gradient, a focus and directrix of a parabola, locus of points satisfying a certain condition? [5] The only approach to overcome this obstacle is by using technology [9], that is computer with dynamic mathematics softwares and one of them is GeoGebra [8]. In this relation, a *mathlet*, a small program which is used to explore a certain mathematical concept, is very well known. *Mathlet* example in visualizing the concept of parabola -- a locus of points which are equidistant from a point (called focus) and a line (called a directrix)-- is as follows. [9]

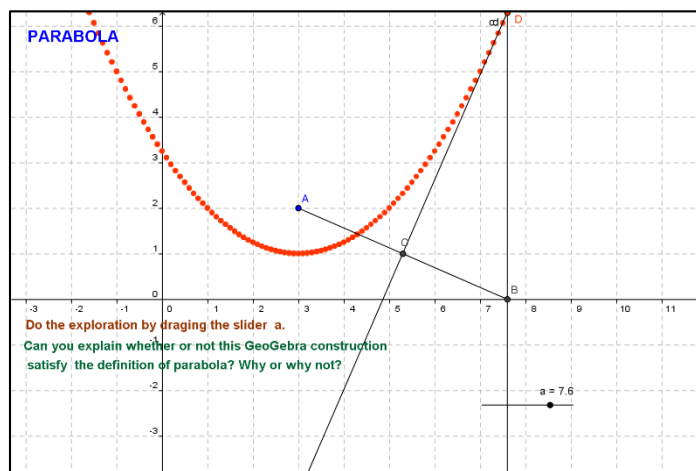


Figure 1: *Mathlet* to explore parabola.

With *mathlet* like the previous one, students will explore the concept of parabola such as whether or not the definition is satisfied. *Mathlet*, is also a very efficient tool to give students a sense of surprise, and from this surprise, hopefully, they will be interested in constructing proof of the concepts behind it. Here is an example.

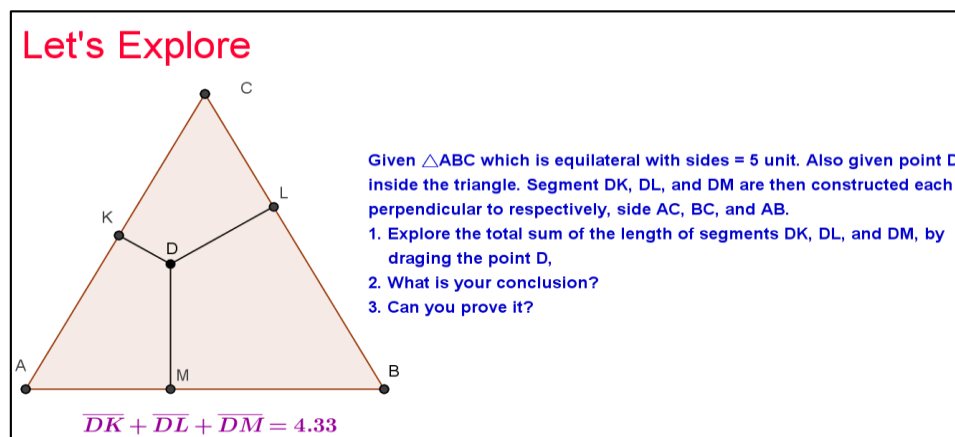


Figure 2: The exploration of The Viviani Theorem.

Mathlet visualization like this will give students another kind of representation of the mathematical concepts behind it. According to the Theory of Multiple Intelligence, humans have many kinds of intelligence, and one of them is a visual intelligence. Surprisingly, visualizations are rarely used in learning mathematics, in spite of its abundant appearance in students life all the day long. Albert A. Cuoco [3] states that: “By helping people visualize and experiment with mathematical phenomena, modern computer technology have changed all people learn and work. In school, they can influence how mathematics is learnt and taught.”

Other factors making GeoGebra *mathlet* so powerful is its ability to give instant feedback and multiple representation of mathematical concepts. Giving instant feedback is very important feature of *mathlet* since students will instantly know whether their responds are correct or wrong, and accordingly make improvements. Meanwhile, displaying various representations will make students realize that mathematical concepts are in fact interrelated, that is a concept can be represented algebraically, numerically, or visually [5]. Especially visual representation, will help visual students a lot since they can understand ideas more easily using visualization. So far, in the teaching-learning

mathematics, these visual students are rarely being given attention and helps. Teachers usually treat all students similarly, and deliver their teaching-learning analytically and rarely visually.[10,11]

3. Mathematics assessment software IMathAS

Another free and open source educational software, which is very useful in making qualified mathematics web, is IMathAS. This software is especially build to mathematics and many other subjects using mathematics. The interesting features of this software is its ability to display mathematical symbols and graphics perfectly, including dynamic graphics (Figure 4) produced by other software such as GeoGebra, as well as randomize items whether their order or their data. These features are very distinctive features of IMathAS compared to others software available. For example, if we want to ask about the gradient of a line which pass through two certain points, IMathAS is not only capable of randomizing the occurrence of this item, but also randomizing those two points (that is the item data). Therefore, theoretically each students can be planned to work out different problem.

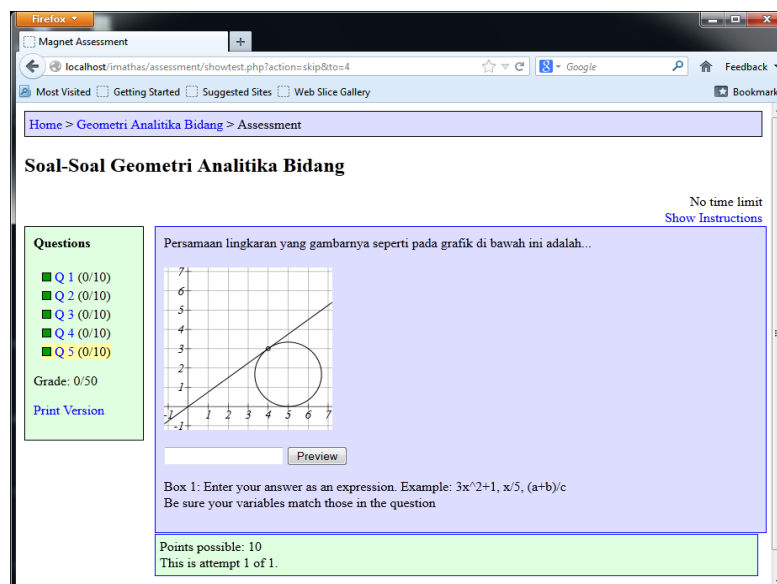


Figure 3. IMathAS display for a certain mathematical

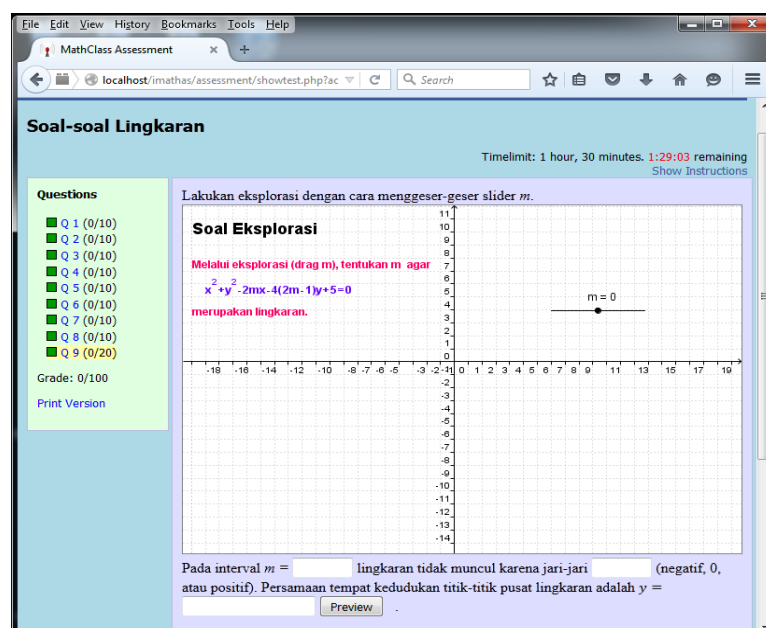


Figure 4. Explorative problem in IMathAS.

4. Results and discussion

To increase students' engagement in learning Analytic Geometry and to monitor their progress during learning process, a Mathematics e-learning called *MathClass* was built. This web set up was then followed by a Classroom Action Research (CAR) [11]. This research have been carried out using 2 classes consisting of 65 students of semester III of Department of Mathematics Education in academic year 2015/2016. In the starting period of the research, many obstacles should be overcome, e.g. many students still do not know how to input symbolic answers to the test being asked. Also, there is some instability with the web, that is, some correct answer is marked as incorrect by the web. To overcome this problems, we asked students to redo the test and submit their answer as a hard copy.

At the second period of the CAR, we thought that the web should be used as a place to learn. Therefore, we then set up a test which can be answered by students repeatedly until they get the right answer. Because the capability of the software to randomized the test data, students will always have different problems to work out. And because their progress will always be monitored, then they will be forced to do the problems. This is really a good way to make students learn. Bellow are results obtained during this period and notice that some students were able to achieve his/her maximum score (i.e. 80).

The figure consists of two screenshots of the IMathAS web application. The left screenshot shows the 'View Scores' page for a test titled 'Grades for Soal-soal Lingkaran'. It displays a table with columns for Name, Grade, %, Last Change, and Time Spent. The right screenshot shows a detailed view of the scores for a specific test, listing individual student names, their scores, percentages, and time spent.

Name	Grade	%	Last Change	Time Spent
3a, Djuarna	80	80%	10/13/15 10:04pm	53 min (47.5 min)
3a, Sanistiawati	10	10%	10/14/15 3:55pm	37 min (34.5 min)
3a, Suardani	20	20%	10/15/15 9:17am	74 min (36.9 min)
3a, Wirapathi	60	60%	10/14/15 1:53am	81 min (70.5 min)
Amelia, Lely	-	-	-	-
Antinikadek, Juni	0 (IP)	0%	Never submitted	-
Astiani, Linda	50	50%	10/14/15 3:36pm	68 min (62.6 min)
Astuti, Desi	30	30%	10/13/15 9:31pm	55 min (52.8 min)
Auliya, Jihan	30	30%	10/14/15 10:14am	44 min (43.5 min)
Ayufajarininiwayan, Tresneta	30	30%	10/15/15 11:04am	52 min (52 min)
Cahyaniputu, Intanc	0 (IP)	0%	10/13/15 7:15pm	7 min (6.6 min)
Criesthyanieluht, Mega	20	20%	10/14/15 1:18pm	28 min (25.7 min)
Damayantikadek, Dwi	30	30%	10/13/15 11:18pm	59 min (39.6 min)
Dewi, Krisnawa	20	20%	10/14/15 10:17am	38 min (37.7 min)
Dianwibawakadek, Ega	0	0%	10/13/15 8:07pm	4 min (4.1 min)
Dwiyantikadek, Gita	0	0%	10/14/15 2:35pm	4 min (4.1 min)
Emelantantri, Ade	30 (IP)	30%	10/13/15 12:36am	91 min (62.9 min)

Name	Grade	%	Last Change	Time Spent
Puspadevi, Candra	0 (IP)	0%	10/15/15 9:47am	22 min (21.2 min)
Puspitasari, Diah	0 (IP)	0%	10/14/15 6:02pm	5 min (4.4 min)
Putrawijayaiputu, Agusw	20	20%	10/14/15 5:23pm	58 min (57.9 min)
Ridwanmd, Asep	30	30%	10/13/15 11:09pm	80 min (80.5 min)
Satyanugraha, Koji	80	80%	10/14/15 4:40pm	54 min (31.4 min)
Setiavatidewazay, Oka	-	-	-	-
Setyadi, Aldy	90	90%	10/14/15 4:12pm	45 min (43 min)
Sintiyadewi, Aris	30 (IP)	30%	10/14/15 11:55am	90 min (90.1 min)
Sukadarmaketut, Adi	40	40%	10/15/15 11:23am	90 min (42.4 min)
Sukma, Mika	-	-	-	-
Suryatamagade, Andi	90	90%	10/15/15 1:04am	47 min (44.7 min)
Susmawati, Riza	30	30%	10/14/15 1:14pm	45 min (44.6 min)
Tejariani, Shinta	20	20%	10/14/15 12:16pm	90 min (72.8 min)
Tejawirasanti, Novita	30	30%	10/14/15 2:47pm	48 min (48.3 min)
Trisna, Cintya	50	50%	10/14/15 4:32pm	90 min (84 min)
Udayani, Wahyu	30	30%	10/14/15 10:58am	26 min (26.2 min)
Widayana, Wilyoga	20	20%	10/14/15 11:09am	7 min (7.2 min)
Wijaya, Bayu	90	90%	10/14/15 1:24am	50 min (48.7 min)
Yasa, Sudana	90	90%	10/14/15 12:46pm	48 min (41.3 min)
Yasaidewamd, Krisna	30	30%	10/13/15 11:16pm	88 min (77.9 min)
Average	34.4	34.4%	-	48 min (42 min)

Meanings: *italics* available to student, IP-In Progress (some questions unattempted), OT-overtime, PT-practice test, EC-extra credit, NC-no credit
* Has exception LP Used latepass

Figure 5. Students' result on test about a circle

So, in this cycle the average students score is 34.4 out of 100. This results, of course, is not very encouraging. This poor results is partly caused by uncommon way students achievement is assessed, that is by using web. In other words, students are still in transition state, from traditional assessment system to online assessment system. From the report is also clear that problem number 9 is rather difficult for students, while problem number 1, 2, and 5 are quite easy to students.

In cycle III, where students had been used to method used in learning, and which used Parabola and Ellipse as materials for assessment, it was obtained that the average students score has increased to become 65.6. This result was encouraging although was still not very satisfying.

Results obtained from the final test showed that the average of students score is 58. Compared to the previous results, i.e. 36, this average increased as high as 22, which is quite significant. In addition, based on the analysis of students responds, it was found that the e-learning was very useful to students and they have learnt a lot because their engagement were always being monitored and used to

determined their final marks. In conclusion the implementation of the e-learning was successful in improving students' engagement and accordingly their achievement.

5. Conclusion

This study has been carried out to investigate the effect of e-learning in improving students engagement and achievement. The problem of the study arose from experiences that students' engagement in this course were very low. Therefore the intention of this CAR was to try to improve students' engagement for the course by the implementation of an e-learning complete with its GeoGebra *mathlet* and its online assessments. Through this e-learning, students engagement and progress were monitored, so they are forced to get involve in the process of learning. From the results obtained, it can be said that the use of e-learning with its *mathlet* and online assessments have been quite successful in improving students' engagement and achievement.

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