Using geogebra to develop students understanding on circle concept

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Abstract. The circle is an important concept that is taught from basic to university level. But in reality there are still difficulties in learning the circle, so that required learning media such as with Geogebra. This research is quasi-experimental research with the aim of analyzing students' understanding of the concept of circle and attitude of students to learning. The study population was all students who have studied the analytical geometry course for the 2017/2018 school year at one of the universities in Indonesia. The sample was selected by purposive sampling. Class A as an experimental class with geogebra learning, while class B as a control class using teaching manipulatives. Before and after the course they were examined test and the results were evaluated. The analysis data shows the increase of students' understanding of the concept of circle in the experimental class (using Geogebra) is higher than the control class (using manipulatives). Students' attitude toward learning using Geogebra is positive.

1. Introduction
The circle is an important concept, so it is taught in elementary school to college. In this concept, students learn abstract abilities, visual, and other high-level math skills [1]. However, students experience difficulties in the concept of geometry [2-4]). Understanding students in the concept of low circle. The low achievement of students in the circle, seen from as much as 38.18% of students in the class can not determine the equation tangent of the circle [5]. In addition, there are student errors in determining the center point and radius of the circle [6]. In general, in determining the equation of the circle (determining the center point and radius of the circle), students have misconception by correlational concept and theoretical concepts simultaneously [7]. So changes in the teaching of geometry are necessary to take care of students’ difficulties [8]. One of them with software Geogebra.

The basic idea of the software Geogebra is to join algebra, geometry, and calculus, which other packages treat separately, into a single easy-to-use package for learning and teaching mathematics from elementary through university level, it is available free from the Internet , has been translated to 36 languages [9]. Geogebra provides many possibilities to help students obtain an intuitive feeling and to adequately visualize math processes [10]. Geogebra can be beneficial in terms of the students' visibility and conceptual thinking [11]. Without geogebra, students can not handle mathematical objects easily [12], and with the help of the Geogebra so the process of teaching and learning becomes more effective [13]. Research shows, using Geogebra in learning, the visuality of the students 'attention increases towards the math lessons, which predominantly consist of abstract concept [14]. The other study shows that the use of Geogebra raise the students' performance in learning coordinate
The study showed that Geogebra as a supplement to constructivist instruction is more effective than constructivist teaching method [16].

Research on the application of circle concept learning has been carried out [1, 17, 18]. The results of the study showed that there are differences in students' mathematics learning creativity between students who use the Two Stay Two Stray, Numbered Heads Together, and Think Pair Share learning models [18]. Budiman also conducts conventional learning research to improve students' understanding of the concept of circles and the recommendation is that further learning use learning media [1]. Emilya et al. developed an open-ended prototype that had a potential positive effect on students' reasoning even though there were still poor student reasoning abilities [17]. In this study, teaching of circle concept with Geogebra and its effect on attitude of students are analyzed.

2. Method

This research design is quasi experiment with pre-test post-test control group design. The experimental class is trained on circle concept by using Geogebra. Control class is trained on it by using manipulatives, denoted as follows [19].

\[
\begin{array}{ccc}
O_1 & X & O_2 \\
\hline
O_1 & \hline
O_2
\end{array}
\]

Table 1 illustrates the experimental pattern of this research.

| Class     | Observation Pre-measurement | Experimental Process Pre-measurement | Observation Post-measurement |
|-----------|-----------------------------|-------------------------------------|------------------------------|
| Experimental Class | Circle concept pre-test | Learning using geogebra | Circle concept post-test |
| Control Class    | Circle concept pre-test | Learning using manipulatives      | Circle concept post-test   |

The population of this study was a student of the mathematics education department who studied analytical geometry for the 2017/2018 school year at one of the universities in Indonesia. Selection of sample by purposive sampling. Class A has been determined by using geogebra and class has been determined by using manipulatives. So the class A was called as the experimental class, Class B was called as the control class. Table 2 illustrates the range of the students.

| Class       | N | %  |
|-------------|---|----|
| Experimental| 29| 47 |
| Control     | 32| 53 |
| Total       | 61| 100|

Before learning, all samples were given a written test on a circle using paper and pencil. Whole teaching was conducted by researcher. The experimental class were trained with Geogebra materials of circle concept, which were prepared by researcher or taken from sources. The control class were trained with manipulatives in accordance with lecture their class. The manipulatives we have created are in articles [2, 20-22] that are free to download on the internet. This manipulatives are certified Intellectual Property Rights in Indonesia.

The lesson materials were prepared by using Geogebra. The content of them was constituted the specific pieces of circle concept, and the tutorial questions. Figure 1 illustrates the Geogebra materials, which are prepared by researcher. After learning, the sample was given a written test on paper and pencil about the concept of a circle using paper and pencil. In addition, an attitude scale test was also given.
At the period of research, the steps, which are mentioned below, were followed.

- Preparing and developing data collecting tools.
- Preparing the Geogebra materials, which are used during the lesson.
- Specifying the experimental and control class
- Making pre-post measurements with data collecting tools. As for the problem as follows.
  1) Find the center and radius of the circle with the equation $2x^2+2y^2+5x-y+10=0$.
  2) Find the following circle equations:
     a. Through $(3,2)$ and center $(2,-1)$.
     b. Through $(1,1)$, $(2,2)$, and $(3,4)$.
     c. Located in quadrant II, tangent to the coordinate axes and has radius 3.
- Pre-test in both classes.
- Application of learning in both classes.
- Post-test in both classes.
- Analyzing the data and used statistical techniques.

3. Results and Discussion

At this part of research, the findings and their assessment, which are acquired by statistical techniques, are given. Table 3 illustrates the results of pretest descriptive data, which are used for analyzing the pre-test on experimental and control class. The descriptive data are as follows.

|        | Code   | N  | Mean  | Std. Deviation | Max | Min |
|--------|--------|----|-------|----------------|-----|-----|
| Control | 32     | 36,45 | 23,91 | 81,25           | 0   |     |
| Experimental | 29 | 18,59 | 15,88 | 50             | 0   |     |

According to Table 3, the mean and standard deviation in both groups are different.

Table 4. Test the normality of pretest data.

| Code | Kode     | Shapiro-Wilk Statistic | df | Sig. |
|------|----------|------------------------|----|------|
| Control | Kontrol   | 0,95                   | 32 | 0,15 |
| Experimental | Eksperimen | 0,89                   | 29 | 0,01 |

Table 4 shows that one class comes from not normally distributed population. Thus, the average early similarity test results in both classes used the mann-whitney test [23].
Table 5. Non-parametric test of pretest data.

| Null Hypothesis | Test                          | Sig. | Decision       |
|-----------------|-------------------------------|------|----------------|
| The distribution of Control and experiment class is them same across categories | Independent-Samples Mann-Whitney U Test | 0.002 | Reject the null hypothesis |

Asymptotic significances are displayed. The significance level is 0.05.

Based on mann-whitney test in table 5 the significance value is less than 0.05. This means the two classes have significantly different initial abilities. So as to see students' improvement in concept of circle using normalized gain data. The normalized gain calculation according to Meltzer [24] follows:

\[
\text{Normalized Gain (g)} = \frac{\text{postest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}
\]

The descriptive data from the normalized gain data of the control class and the experimental class are in Table 6.

Table 6. Normalized gain descriptive data.

| Code | N  | Mean | Std. Deviation | Min | Max |
|------|----|------|----------------|-----|-----|
| Class | Control | 32   | 0.76          | 0.27 | 0.05 | 1   |
|      | Experimental | 29   | 0.92          | 0.14 | 0.55 | 1   |

In table 6 it can be seen that the mean and standard deviation of the normalized gain in the control and experimental classes are 0.76, 0.92, 0.27, and 0.14, respectively. So that descriptively look different. So, the average difference test is done, but the normality test in Table 7 is done.

Table 7. Tests of Normality data gain ternormalisasi.

| Code | Shapiro-Wilk Statistic | Df | Sig. |
|------|------------------------|----|------|
| Class | Control | 0.82 | 32 | 0.00 |
|      | Experimental | 0.66 | 29 | 0.00 |

Based on table 7 both classes come from a not normally distributed population. So test the average difference normalized gain data using the mann-whitney test [23].

Table 8. Non-parametric test of normalized gain data.

| Null Hypothesis | Test                          | Sig. | Decision       |
|-----------------|-------------------------------|------|----------------|
| The distribution of Control and experiment class is them same across categories | Independent-Samples Mann-Whitney U Test | 0.002 | Reject the null hypothesis |

Asymptotic significances are displayed. The significance level is 0.05.

Table 8 shows that the significance value is less than 0.05. This means that the normalized gain of the experimental class whose learning uses Geogebra and the control class whose learning using manipulatives differs significantly. So the increase of understanding on the concept of circle in the experimental class is higher than the control class.

Analytical geometry is a geometry that is solved algebraically and includes difficult subjects for students because it is abstract. So it takes the learning media to help students in learning, one of them Geogebra. Geogebra is a software that can bridge between geometry and algebra [9].

These results provide an illustration, that learning geometry on the concept of circles by using Geogebra can improve students' understanding of concepts. This is in accordance with the research of
Chang, et al [25], the experimental results indicate that, with the exception of recognition ability, geometry software produces significant learning effects on visual association, description/analysis and abstraction/relation as well as overall geometric thinking. Other than that, Geogebra makes it easy for students to visualize the concept of circles, improve student performance, and make learning more effective [10-16].

Research [26] also shows that software geometry had a positive effect on students' spatial visualization skills. Clements [27] reported benefits of using computer manipulatives for practical / pedagogical benefits are as follows:
1. Providing another medium, one that can store and retrieve configurations.
2. Providing a manageable, clean, flexible manipulative
3. Providing an extensible manipulative
4. Recording and extending work.

To find out the students' responses to learning using Geogebra, we gave a questionnaire to the students. Questionnaire contains 8 positive and negative statements. The results are in Table 9.

| Statement                                           | Strongly agree (%) | Agree (%) | Disagree (%) | Strongly disagree (%) |
|-----------------------------------------------------|--------------------|-----------|--------------|-----------------------|
| 1. Geogebra is beneficial to me.                     | 60                 | 30        | 10           | 0                     |
| 2. Geogebra improves my concentration in learning.   | 23.3               | 60.0      | 13.3         | 3.3                   |
| 3. Geogebra is not interesting.                      | 0                  | 6.7       | 50           | 43.3                  |
| 4. Geogebra can reduce my difficulty in learning.    | 20.0               | 73.3      | 3.3          | 3.3                   |
| 5. Geogebra can not improve the understanding of abstract concepts. | 0                  | 6.7       | 83.3         | 10                    |
| 6. Geogebra can make me enjoy in learning            | 13.3               | 76.7      | 6.7          | 3.3                   |
| 7. Geogebra can be used in all concepts of analytic geometry. | 23.3               | 60.0      | 13.3         | 3.3                   |
| 8. Geogebra can be used also in school.              | 43.3               | 56.7      | 0.0          | 0.0                   |

In order to take student's opinions on learning with Geogebra, the statement were given. To choose each of them (strongly agree – strongly disagree). 1 point was specified as the lowest score for strongly disagree, 2 point was specified as for disagree, 4 point was specified as agree, 5 point was specified as the highest point for strongly agree. Table 9 illustrates the students' answers and their percentage about course with Geogebra. When the data of table were analyzed, students' attitude toward learning Geogebra is positive.

So that students' positive students towards the use of Geogebra in geometry learning helps students in understanding the concept of circles. This is corresponds to the statement with Ruseffendi [28] which states that positive attitudes toward mathematics can be positively correlated with learning achievement.

4. Conclusion
The conclusion of this study is:
1. The increase of understanding on the concept of circle in the experimental class (uses Geogebra) is higher than the control class (uses manipulatives).
2. The students' attitude toward learning Geogebra is positive.

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References

[1] Budiman H 2014 Pembelajaran Geometri Lingkaran dengan Metode Konvensional dan Pengaruhnya pada Siswa Jurnal Kajian Pendidikan 4 1

[2] Purniati T, Sudihartinih E, 2015 Visual Aids in Analytical Geometry Course in Conic Concept Proceedings International Seminar on Mathematics, Science and Computer Science Education

[3] Sari P P 2016 Analisis Kasus Rendahnya Prestasi belajar Matematika Siswa pada Materi Irisan Kerucut dan Solusi Pemecahannya di Kelas XI IA 2 SMAIT NUR HIDAYAH Proceedings at the National Conference on Research on Mathematics and Learning at Muhamadiyah University of Surakarta

[4] Sudihartinih E, Mulyana E, 2014 Perkuliahan Geometri Transformasi dengan Pendekatan Kontruktivisme untuk Meningkatkan Level Berpikir Geometri van Hiele Jurnal Pendidikan Matematika Sigma Didatika 3 1 12-16

[5] Rumasoreng M I, Sugiman 2014 Analisis Kesulitan Matematika Siswa SMA/MA dalam Menyelesaikan Soal Setara UN di Kabupaten Maluku Tengah Jurnal Riset Pendidikan Matematika 1 1

[6] Imswatama A, Muhassanah N 2016 Suska Journal of Mathematics Education 2 1 1–12

[7] Wardani E P, Mardiyana, Subanti S 2016 Analisis Miskonsepsi Siswa Pada Materi Pokok Lingkaran Ditinjau dari Kesiapan Belajar dan Gaya Berpikir Siswa Kelas XI IPA SMA N 3 Surakarta Tahun Ajaran 2013/2014 Jurnal Elektronik Pembelajaran Matematika 4 3 328-340

[8] Smith R R 1940 Three Major Difficulties in the Learning of Demonstrative Geometry: Part I. ANALYSIS OF ERRORS The Mathematics Teacher 33 99-134

[9] Hohenwarter M, Hohenwarter J, Kreis Y, Lavicza Z 2008 Teaching and calculus with free dynamic mathematics software GeoGebra 11th International Congress Mathematical Education, Mexico

[10] Dikovic L 2009 Implementing Dynamic Mathematics Resources with GeoGebra at the College Level iJET 4 3

[11] Akkaya A, Tatar E, Kagizmanli, T B 2011 Using Dynamic Software in Teaching of the Symmetry in Analytic Geometry: The Case of GeoGebra Procedia Social and Behavioral Sciences 15 (2011) 2540–2544

[12] Choi K S 2010 Motivating Students in Learning Mathematics with Geogebra. Annals Computer Science Series 8 2

[13] Tran T, Nguyen N G, Bui M D, Phan A H 2014 International Journal of Learning, Teaching and Educational Research 7 1 44-57

[14] Reis Z A, Ozdemir S 2009 Using Geogebra as an information technology tool: parabola teaching Procedia Social and Behavioral Sciences 9 1 565–572

[15] Saha R A, Ayub A F M, Tarmizi R A 2010 The Effects of GeoGebra on Mathematics Achievement: Enlightening Coordinate Geometry Learning Procedia Social and Behavioral Sciences 8 1 686–693

[16] Zengin Y, Furkan H, Kutluca T 2012 The Effect of Dynamic Mathematics Software Geogebra on Student Achievement in Teaching of Trigonometry Procedia - Social and Behavioral Sciences 31 1 183 – 187

[17] Emilya D, Darmawijoyo, Putri R I I 2010 Pengembangan Soal-Soal Open-Ended Materi Lingkaran untuk Meningkatkan Penalaran Matematika Siswa Kelas VIII Sekolah Menengah Pertama Negeri 10 Palembang Jurnal Pendidikan Matematika 4 2

[18] Kusumaningrum R, Budiyono, Subanti S 2015 Eksperimentasi Model Pembelajaran Kooperatif Tipe Two Stay Two Stray, Numbered Heads Together, dan Think Pair Share pada Materi Lingkaran Ditinjau Dari Kreativitas Belajar Matematika Siswa SMP Negeri di Kabupaten Sukoharjo Jurnal Elektronik Pembelajaran Matematika 3 7 705-716
[19] Ali M 2014 RISET KUANTITATIF (Metodologi dan Aplikasinya) Paper on thesis guidance training at Universitas Pendidikan Indonesia on the December 3, 2014

[20] Sudihartinih E, Purniati T, 2017 Meningkatkan Kemampuan Pemahaman Matematis Mahasiswa dalam Perkuliahan Geometri Analitik pada Konsep Irisan Kerucut dengan Menggunakan Alat Peraga Proceedings at the National on Mathematics at UNPAR Bandung Indonesia 12 1

[21] Sudihartinih E, Purniati T 2018 Manipulative’s of Function Translation Proceedings at the IOP Conference 288 1 012063

[22] Sudihartinih E, dan Purniati T 2016 ALAT PERAGA IRISAN KERUCUT Proceedings at the National on Mathematics at UNPAR Bandung Indonesia 11 1

[23] Ruseffendi E T 1993 Statistika Dasar untuk Penelitian Pendidikan Bandung: Depdikbud

[24] Sudihartinih E 2014 Meningkatkan Kemampuan Pemahaman Matematis Mahasiswa dalam Perkuliahan Geometri Analitik pada Konsep Irisan Kerucut dengan Menggunakan Alat Peraga Proceedings at the National on Mathematics at UNPAR Bandung Indonesia 12 1

[25] Chang K N, Sung Y T, Lin S Y 2007 Developing geometry thinking through multimedia learning activities. Computers in Human Behavior 23 1 2212–2229

[26] Baki A, Kosa T, Guven B, 2001 A Comparative Study of the Effect of Using Dynamic Geometry Software and Physical Manipulatives on the Spatial Visualisation Skills of Pre-Service Mathematics Teachers British Journal of Educational Technology 42 2 291–310

[27] Clements D H 1999 ‘Concrete’ Manipulatives, Concrete Ideas, Contemporary Issues in Early Childhood 1 1

[28] Ruseffendi E T 1991 Penilaian Pendidikan dan Hasil Belajar Siswa Khususnya dalam Pengajaran Matematika Bandung