Developing Ellipse Properties Learning Unit with Computer Assisted Learning through GeoGebra software for Thai High School Students

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Abstract. This study aimed to clarify the developing ellipse properties learning with computer assisted learning through GeoGebra software for Thai high school students. Participants include 40 Grade 10 students who were studying in Khon Kaen University Demonstration secondary school, academic year of 2016. Methodology regarded qualitative research. The intervention of Geometry with GeoGebra was provided for semester. The paper will explain how the GeoGebra will be provided for the opportunity students to construct and dynamically visualize geometric figures. GeoGebra builds a dynamic ellipse to show the characteristic of the points that form the ellipse. And, students may find the relation between two points on the ellipse by using GeoGebra. The unit provide students to generate their representation to explain ellipse definition and properties when they on tasks with the GeoGebra.

1. Introduction
Geometry is not only part of ancient cultures such as Indian, Babylonian, Egyptian, Chinese and Greek but also one of the core topics included in the modern mathematics syllabus that was approved by National Council for Teachers of Mathematics (NCTM). Geometry consists of theorem and many applied problem to solve. Geometry is an integral part of life as it has a bearing on aspects of life such as architecture design, art, building, construction, interior design and so on. It is connected to the visual, aesthetic and intuitive human facilities [6].

Ellipses find wide applications in mathematics, physics, and engineering. Elliptic shapes are used in architectural and design forms. It is difficult to build the ellipses form by hands because they have a continuously varying curvature. If an elliptic arch is to be built, each piece of the structure needs to be of a different shape [2]. Students can make sense of ellipses through a clear geometric derivation of the mathematical theory (\(\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1\)) that governs all four arc constructions of the ellipse. Based on this formula, students could plot graph to display the ellipses. And, also simplified computations using a computer could build the ellipses. It seems that students need to think about moving the continuous points to build the ellipses.

Transformation geometry may comprise of motions such as translation, reflection and rotation and also with dilations or shrinking and enlargement [1, 10]. explained transformation geometry as the study of figures and properties of figures conserved by reflections, translations, rotations, and their groupings. It provides the opportunity for learners to recognize and perform changes in the coordinates.
of the image of objects regarding their position, orientation, direction and size within a coordinate plane. In another word, Transformation geometry is defined as “a subset of geometry in which students learn to identify and illustrate movement of shapes in two and three dimensions. Transformation geometry, which can be characterized as the study of geometric objects in the plane, links the properties of transformations to the properties of objects. Geometric transformations should provide discovering and/or proving characteristics of geometric objects; forming patterns like friezes, rosettes, wallpapers; classifying geometric objects; perceiving the chirality of an object. The three types of movement are slides (translations, as when a figure is moved on a page), flips (reflections, that is, when a figure is turned over in three dimensions), and turns (rotations, when a figure is rotated 90° without being flipped).” [7]. In the present study, transformation geometry includes the patterns such as fractals, and the movement of the figures such as reflection, translation, rotation and combination of these.

GeoGebra, an open source dynamic geometry software, provides the opportunity to construct and dynamically visualize geometric figures [4,5], Fahlberg-Stojanovska and Trifunov [4] investigated a study to show how GeoGebra improved students’ understanding of construction and geometric proof. They conducted a qualitative exploratory study by using tasks that include construction and proof problems for the relations on the triangles. The results showed that using GeoGebra in these tasks improves the percentage of students that are able to solve the triangle construction and proof problems [4]. This result is consistent with that of Christou et al [3] and Pandiscio [9] in terms of DGs’s effectiveness in justification and verification of both geometric and algebraic problems’ solutions.

Hohenwarter and Fuchs [5] argued some advantage of the GeoGebra. It promotes guided discovery, cooperative and experimental learning, multiple presentations and students’ products in mathematics. Students can manipulate objects by dragging around the plane of drawing or using sliders to test mathematical ideas and see how these movements affect other variables. In this way, students have the opportunity to solve problems by investigating mathematical relations dynamically. Users can personalize their own creations through the adaptation of interface (e.g. font size, language, quality of graphics, color, coordinates, line thickness, line style and other features). The algebra input allows the user to construct new objects or to modify the existing ones by the command line. The worksheet files can easily be published as Web pages.

In order to provide transformation geometry, the GeoGebra need to be introduced to the geometry classroom. GeoGebra has the potential to encourage the student-centered learning, active student participation, collaborative learning, and discovery learning by experimenting mathematical ideas, theorems and using interactive explorations (Preiner, 2008). This study tried to develop the intervention of ellipse learning activities to enhance students to make sense of ellipses as transformation geometry through Geogebra.

2. Intervention of GeoGebra Ellipse Learning activities

Students access the GeoGebra software via http://www.geogebra.org. GeoGebra, an open source dynamic geometry software, provides the opportunity to construct and dynamically visualize geometric figures. The intervention of GeoGebra ellipse learning activities in this study may starting from drawing for understanding of definition of ellipse, and then using GeoGebra for construction and geometric proof, and constructing the ellipse and solving problems of ellipse.

2.1. Drawing on GeoGebra for understanding of definition of ellipse

The GeoGebra will be used to challenge students to construct meaning of ellipse definition. Ask students to draw the ellipse by following the definition of ellipse. The definition of ellipse is a regular oval shape, traced by a point moving in a plane so that the sum of its distances from two other points (the foci) is constant, or resulting when a cone is cut by an oblique plane that does not intersect the base. Students may draw the ellipse as below. This drawing may enhance students to understand the relation of PF + PF’equal a constant which also equal double times of vv’. Students may draw this relation as the figure 1.
2.2. Movement of shapes to proof the representation about ellipse

Constructing meaning of ellipse through some external representations, such as formula and graph, will be provided through GeoGebra transformation geometry which students to identify and illustrate movement of ellipse shapes. The GeoGebra enhances students to recognize and perform changes in the coordinates of the image of objects regarding their position, orientation, direction and size within a coordinate plane. Students will be asked to rotate and move points for shapes to proof the representation about ellipse. Students make sense of ellipses through a clear geometric derivation of the mathematical theory \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \). They tried to explain the relation the points on the ellipse by rotate the points on the GeoGebra as the figure 2.

![Figure 1: Drawing the relation of PF + PF’ equal a constant](image1)

**Figure 1:** Drawing the relation of PF + PF’ equal a constant

![Figure 2. Rotate to explain the relation the points on the ellipse](image2)

**Figure 2.** Rotate to explain the relation the points on the ellipse
2.3. Constructing the ellipse and solving problems of ellipse.
Students were enhanced to construct meaning of ellipse through dynamically visualize geometric figures. It indicates that GeoGebra improved students’ understanding of construction and geometric proof. They conducted a qualitative exploratory study by using tasks that include construction and proof problems for the relations on the ellipse. The examples of GeoGebra learning activities were provided as following. According to the figure 3, student pointed the position P on the ellipse and then he or she dragged the position P to another point as showed in the figure 4. To do so, student may learn the relation between PF1 and PF2 where sum of PF1 and PF2 is constant. It is a property of ellipse. This could mention that the GeoGebra representationally connected students to construct meaning of ellipse.

![Figure 3](image1.png)

**Figure 3.** Constructing the ellipse and solving problem

![Figure 4](image2.png)

**Figure 4.** Constructing the ellipse and solving problem

3. Conclusion
The paper could show a method of utilization of computers by the GeoGebra as computer assisted learning about geometry. The GeoGebra could provide students chance to learn geometry as transformation geometry. It provides some ideas to enhance student active learning by experiment mathematical ideas about geometry. The drawing of ellipse is easily done which students could individually make sense definition of ellipse. The activities of rotate and move the coordination on the ellipse could provide the dynamics learning about ellipse. The GeoGebra also could employ to provide activities of proof and solving problems about the geometry.

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