

Creating Dynamic Learning Environment to Enhance Students' Engagement in Learning Geometry

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Abstract. Learning geometry gives many benefits to students. It strengthens the development of deductive thinking and reasoning; it also provides an opportunity to improve visualisation and spatial ability. Some studies, however, have pointed out the difficulties that students encountered when learning geometry. A preliminary study by the author in Bali revealed that one of the main problems was teachers' difficulties in delivering geometry instruction. It was partly due to the lack of appropriate instructional media. Coupling with dynamic geometry software, dynamic learning environments is a promising solution to this problem. Employing GeoGebra software supported by the well-designed instructional process may result in more meaningful learning, and consequently, students are motivated to engage in the learning process more deeply and actively. In this paper, we provide some examples of GeoGebra-aided learning activities that allow students to interactively explore and investigate geometry concepts and the properties of geometry objects. Thus, it is expected that such learning environment will enhance students' internalisation process of geometry concepts.

1. Introduction

Improving the effectiveness of geometry instruction, such as improving students' engagement, providing learning condition to stimulate cognitive activities, encouraging students to discuss and to share, is not always easy to be implemented. There are some obstacles that challenge teachers, one of them is the tendency to use the traditional approach. In a traditional geometry course, students are told definitions and theorems and assigned problems and proofs; they do not experience the discovery of geometric relationships, nor invent any mathematics [1]. In line with this, Reys et al.[2] suggest that geometry is best learned in a hands-on, active manner, one that should not rely on learning about geometry by reading from a textbook. A study by the author revealed that most teachers have difficulties in delivering some geometry concepts [3]. It was partly due to the lack of availability of media that can visualise geometry concepts. Teachers are aware of the importance of media, but they do not fully utilise media in their geometry instruction. If they use media, then their media is static ones, it cannot be manipulated dynamically.

One possible solution to overcome this problem is to create a technology-aided learning environment. The integration of computer in the instruction will assist students to imagine geometry concept and to make observation [4]. Some studies have shown that technology can be used in the instruction and give positive impacts on the quality of the instruction (see for instance [5]; [6]; [7]). Moreover, technology can be used to strengthen student learning and enhance pedagogy [8]. The use of technology in the instruction has some benefits such as providing students with greater chances of study [9].

There are two forms of technology use in mathematics instructional, i.e., virtual manipulatives and mathematical software tools [10]. Due to the limitation of virtual manipulative to do mathematical



experiments, many teachers use educational software packages that enable both teachers and students to visualise and explore mathematical concepts in their creative ways (Barzel, 2007 in [10]). Examples of educational software are dynamic geometry software, computer algebra system, and spreadsheet [10].

Technology is not intended to replace mathematics. It is intended to support the learning and teaching of mathematics instead. Empirical results obtained from the use of technology give a better insight into the writing of a formal proof. Furthermore, the use of technology in mathematics teaching should support and facilitate conceptual development, exploration, reasoning, and problem-solving[5]. Also, NCTM has stressed that teachers should use technology to enhance their students learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well-graphing, visualising, and computing [11].

2. Dynamic Learning Environment

Integration of technology in geometry instruction necessarily needs a computer software to support the learning process effectively. We choose the second form of utilising technology where a dynamic geometry software (DGS) is employed. DGS has some tools that can be activated by clicking the tool buttons with the mouse. Afterwards, the tools can be applied to do construction, exploration, and investigation. DGS has three main features that usually cannot be found in computer algebra system or spreadsheet, i.e. drag mode, customizable tools, and trace or locus of objects (Graumann, et al., 1996 in [10]).

With the aid of DGS, a dynamic learning environment (DLE) can be established to facilitate geometry instruction. In DLE, students can quickly and accurately explore geometrical objects, discover patterns, and formulate a conjecture. Delivering geometry instruction in a way that encourages exploration and stimulates active participation in the learning are expected to improve the quality of students' learning. Hence, one goal of using DGS is to provide a learning environment which allows students to explore geometry objects and investigate their attributes and properties while preserving the rigorous nature of mathematics. In DLE, students are offered the opportunity to explore, to make a conjecture, to discover, and to experiment in a way that cannot be done with just pencil and paper [12]. DLE enables extensive and instant manipulation through the power of drag mode. This feature allows students to instantly experiment with as many examples as possible and get immediate feedbacks.

In this paper, we use GeoGebra as our DGS because it is free, is easy to operate, and has features to do dynamic exploration. GeoGebra allows teachers and students to conduct exploration easily and interactively, thus encourage students to involve actively in the learning process. In this way, understanding and internalisation of geometry concepts and their properties become easier. GeoGebra positively affects students' learning achievement and improves motivation [4]. The study has shown that students' understanding of mathematics improved after using DGS [13].

3. Examples of Exploration with Geogebra

In the following, we provide some examples of activities that utilise GeoGebra to carry out classroom investigation. These examples provide a dynamic learning environment so that the geometry instruction becomes meaningful and joyful for students.

3.1. Median of a Triangle

The following discussion is adapted from [14]. In GeoGebra graphic window, draw the triangle ABC. Mark a point on one of the sides say side AB. Call this point D. Draw a line through D and parallel to BC. This line intercepts side AC at point E. Draw segments BE and CD and name the intersection of these two segments M. Finally, draw the line AM and extend it to meet side BC at point N. See figure 1a. Ask students to measure and record the length of BN and CN. Students are then requested to move point D with the mouse along the side AB and observe the length of BN and CN. Now, change the shape of the triangle by dragging one of its vertices with the mouse. One possible result of this action is shown in figure 1b. Guide students to conclude that the point N is the midpoint of the side BC, regardless of both the position of D on the side AB and the shape of the triangle. Hence, the segment AN is always a median of the triangle. The next task is to prove that AN is always a median. Teachers can invite students to engage in a discussion to mathematically prove this result.

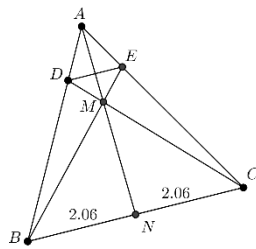


Figure 1a. Segment AN is a median

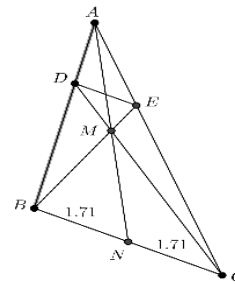


Figure 1b. Different shape of triangle, AN is still a median

The investigation can be continued further on. Teachers may ask students to explore the properties of three medians of the triangle (such as the three medians of any triangle are concurrent; the centroid of a triangle divides each median in the ratio 1:2). We notice that each median divides the triangle into two smaller triangles. Students easily verify using GeoGebra that the area of these two triangles is the same. The three medians divide the triangle into six smaller triangles. The area of these six triangles is always equal regardless of the type of the original triangle. Using GeoGebra, this property can be reinvented by students just by dragging the vertices of the triangle and observe the changes that happen. Students can investigate the type of the triangle for which the six smaller triangles are congruent to each other. An assignment can be given to students to prove the results obtained in this investigation formally.

3.2. Midpoint Quadrilateral

Consider an arbitrary convex quadrilateral. Connect the midpoints of the sides of the quadrilateral to form a new quadrilateral which is known to be a parallelogram. See figure 2. Teachers can provide learning activities supported by GeoGebra-based instructional media to investigate this fact. In GeoGebra, start with four points and construct a convex quadrilateral with these four points as vertices. Mark the midpoint of each side and then join them to form a new quadrilateral.

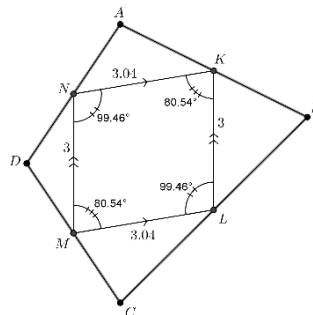


Figure 2. Midpoint quadrilateral is a parallelogram

Ask students to manipulate the original quadrilateral by dragging one of its vertices. Notice that as the shape of the original quadrilateral changes, the shape of the resulted quadrilateral also changes. Students are instructed to observe the resulted quadrilateral and record the measure of all angles, the length of each side, and the position of two opposite sides. In a group, students can discuss and decide that the resulted quadrilateral is a parallelogram. Ask students to replace the original quadrilateral with a square, a rectangle, a rhombus, a trapezium, or a kite. Then, observe and discuss what happen to midpoint quadrilateral. Furthermore, students can investigate the conditions for which the midpoint quadrilateral is a rectangle, a square, a rhombus, or a kite.

3.3. Midsegment of a Triangle

Following the discussion of this topic in [15], we shall use GeoGebra to assist students to formulate the midsegment theorem of a triangle. In the graphic window of GeoGebra, construct an arbitrary

triangle with vertices A, B, and C. Put one point, say M, on any side of the triangle, in this case, the side AB. Construct a line segment through M and parallel to the side BC and cut the side AC at N. See figure 3.

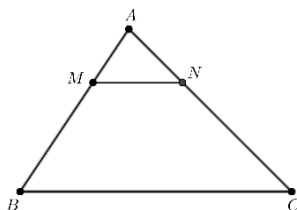


Figure 3. Segment MN is parallel to BC
 with M is an arbitrary point on AB

Determine the ratio AM/BM and AN/CN . Record this ratio on a piece of paper or the worksheet in GeoGebra window. Also, determine the ratio MN/BC . Now, here is the dynamic part of the activities. Teachers instruct students to use the mouse to drag the point M to a new position and note the three ratios. Repeat this process until $AM/BM = AN/CN = 1$. When this happened, teachers ask students to find the ratio MN/BC . Students can repeat these activities for a different type of triangle by dragging one of the triangle vertices to change the shape of the triangle. It is expected that students, after group discussion under teacher's guidance, can state the midsegment theorem.

4. Conclusion

Geometry is a good start to learn more about axiomatic systems and the deductive thinking process. One way to improve the effectiveness of geometry instruction is the integration of technology. Coupling with dynamic geometry software, a dynamic learning environment can be established to provide explorative and multi-representation learning, thus make learning more meaningful. With the aid of GeoGebra-based instructional media supported by well-designed lesson plan, it is possible for students to visualise and investigate geometry concepts and their properties dynamically. It is thus expected that students engage in the learning process more actively and deeply. Therefore, such learning environment will enhance students' internalisation and understanding of geometry concepts.

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