

Using Ornaments to Enhance Students' Proving Skill in Geometry

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Abstract: There are a large number of geometry ornaments that we can find in everyday life. On the other hand, the use of these ornaments in mathematics learning, especially geometry, was still very limited. Geometric patterns or ornaments that there can actually be used as a source of learning mathematics that are full of creativity. Students who learn by means of these ornaments will become more active and increase their interest in the learning activities. In addition, learning with ornament media will enhance students' creativity in making new ornaments, making problems, and solving them with various approaches. Ornaments can also be used as a tool to develop students' skills in proving. Proof is an important part of mathematics. Proof is a tool for understanding mathematics. However, many students have difficulties to learn proof. Most students cannot construct a proof. It might be possible to define learning environments for mathematics classroom that are apt to enhance students' proving competencies. This study is literature review about who to proof geometry properties through the activity of constructing geometry objects or ornaments using geometry software. Interactive geometry software (IGS) is also called Dynamic Geometry Environments (DGEs) is a computer program that allows user to create and manipulate geometric objects. Cabri II Plus is one example of IGS that is specialized in two-dimensional programs from around 30s of similar software. This interactive geometry software has several advantages including being able to make learning geometry more meaningful, can justify a number of concept errors, and the numerical and numerical capabilities of a computer also provide a rich learning environment so students can experiment. Exploration experience using this software also has a good effect on students' mathematical proof. Apart from that, working with interactive geometry software has several advantages compared to working manually, including in terms of accuracy and time.

1 INTRODUCTION

Ornaments or symmetrical patterns in geometry cannot be separated from ethnomathematics. Ethnomathematics is the mathematics used by community groups/cultures, such as the community cities and villages, groups of workers/laborers, professional groups, children of a certain age, indigenous people, and many other groups recognized by the group's general goals and traditions (D'Ambrosio, 2006). In addition, ethnomathematics also related to research that connects mathematics or mathematics education and its relationship to the social and cultural backgrounds, namely research that shows how mathematics is produced, transferred, disseminated and specialized in various cultural systems (Zhang and Zhang, 2010).

One study of cultural systems in ethnomathematics is called the second strand (Vithal and Skovsmose, 1997). The ethnomathematics study at the second level discusses mathematics in traditional culture. Many kinds of traditional cultures around us are using mathematics. The culture, among others, may include geometric patterns and more can be found at various ornaments and buildings such as ornamental patterns in the mosque as a place of worship for Muslims.

There are a lot of geometric patterns in Islamic culture (Abas, 2001). The ornamental patterns are divided into three groups, namely, *Calligraphic*, *Arabesque*, and *space filling patterns*. Most characteristics of these patterns are in the form of stars and roses. Therefore, geometric patterns or ornaments in various buildings can be used as a source of learning mathematics that is full of creativity.

Geometric ornaments are a rich source of creative applications in geometry. Students who learn by means of these ornaments will become more active and increase their interest in the material being taught. In addition, learning with ornamental media will enhance students' creativity in making new ornaments, making problems and solving them with various approaches (Verner, Massarwe and Bshouty, 2012).

Enhancing students' proving skill by creating ornaments using interactive geometry software is the first step in increasing the study of ethnomathematics. The final hope in this study is the further development and use of this tool in increasing the creativity of both students and teachers in mathematics learning.

2 DISCUSSION

2.1 Interactive Geometry Software

Interactive Geometry Software (IGS) is also called Dynamic Geometry Environments (DGEs) is a computer program that allows user to create and manipulate geometric objects. IGS can be divided into two types, namely two-dimensional (2D) and three-dimensional (3D) programs. Cabri II Plus is an example of 2D program from around 30 similar software. The Cabri Geometry was originally designed at IMAG, a collaborative research laboratory between the CNRS (National Center for Scientific Research) and the University of Joseph Fourier, in Grenoble, France. Jean-Marie Laborde started this project in 1985 which aims to facilitate teachers in teaching geometry (Brainville, 2007).

Interactive geometry software has several advantages including being able to make learning geometry more meaningful, can justify some conceptual errors, and the graphic and numerical capabilities of computers providing a rich learning environment so students can experiment freely (Ismail and Kasmin, 2007). This exploration experience also offers hope in building a strong spirit of intuition and geometry estimation that is important in problem solving and theory development in the branch of mathematics. In addition, interactive geometry software is better when compared to manual work because the right images can be made in a short time.

2.2 Creating Ornaments

2.2.1 Ornaments on Stairs

This first ornament is located on the stairs that connects the ground floor with the top floor of a building (Figure 1). The shape of this ornament is square, which are one main square and two squares located in the middle. This ornament is the simplest ornament compared to other ornaments in next section.



Figure 1.

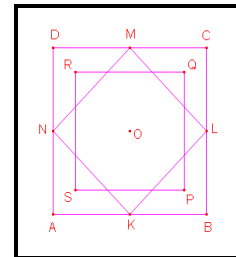


Figure 2.

The ornament is made by creating square of $ABCD$ with Regular Polygon tool located in The Lines Toolbox. Next, creating a midpoint on AB , BC , CD , and DA using the Midpoint tool. The four midpoints are named with letters K , L , M , and N , respectively. The four points are connected using the Polygon tool to form the $KLMN$ square. The $KLMN$ square is then rotated as far as 45° with point O as the center of its rotation with the Rotation tool and forms $PQRS$.

2.2.2 Garden Fence Ornaments

This ornament can be found on the garden fence (Figure 3). The shape of this ornament is the same as the stairs ornament. Therefore, the steps for making this ornamental frame are the same as the steps for making stairs ornament. Next, using the Segment tool, we can create US , BP , CQ , and DR segments, as shown in Figure 4.



Figure 3.

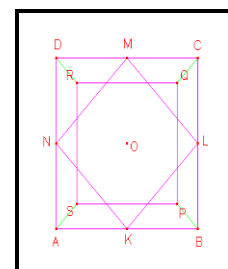


Figure 4.

The next process is to remove the labels from each point (these labels will be used to name the intersection point between the *KLMN* and *PQRS*, the purpose is only to facilitate the illustration of the ornament manufacturing process). The process of creating intersection points between *KLMN* and *PQRS* can be done manually or can also be done simultaneously using the Intersection Point (s) tool. After this step, then next is naming the intersection points as shown in Figure 5. Then points *A* and *F*, *B* and *E*, *C* and *H*, *D* and *G*, *B* and *G*, *C* and *F*, *A* and *D*, and *H* and *E* are connected with the Segment tool so that shown in Figure 6.

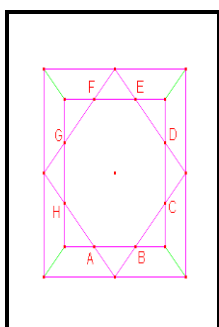


Figure 5.

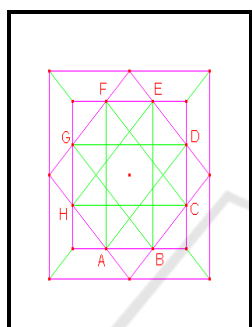


Figure 6.

The coloring of star ornaments located in the middle of the image cannot be done in this process. We need the Polygon tool to make the star. The coloring of contents of an image can be using the fill tool and the coloring of lines can be using color tool. The result of the coloring is shown in Figure 7 and coloring end of the entire ornament shown in Figure 8.

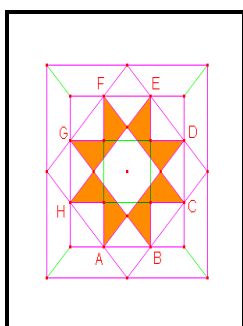


Figure 7

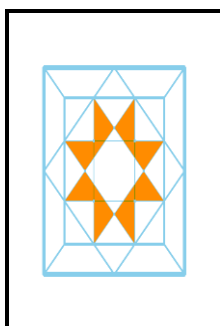


Figure 8

2.2.3 Wall Ornaments I

The next ornaments are one of the two ornaments that can be found on the walls of the building

(Figure 9). The level of complexity of these ornaments is higher than the two ornaments discussed earlier. In addition, this ornament is also one of the ornaments that can easily be found in various Islamic buildings. The reason for choosing this ornament from the second ornament is because this ornament has a higher level of difficulty compared to the second ornament. In addition, the reason for beauty is also used as a reason why this ornament was chosen. There are any ways can be done in designing this ornament. One of them is as follows. The first, we can draw the square used as the ornament frame using the Regular Polygon tool and we name with *ABCD*. If observed, the main shape of the ornament is an octagon. Therefore, we can draw an octagon in a square that we made earlier as shown in Figure 10.



Figure 9.

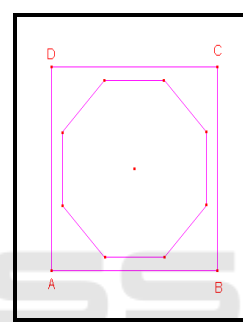


Figure 10.

The next process is to make the midpoint of each side with the Midpoint tool and connect the points by Polygon tool so that it forms a square. The square is rotated as far as 22.5° with the Rotation tool with the center of the polygon as the rotation axis. The results of the rotation later rotated again and so on until three times. Then connect a certain number of points with the Segment tool with the intention as the basis for making the next ornament, as shown in Figure 11. The color of the octagon is changed to another color so that the polygons that will be created later have a different color from the octagon. After that, a new multi-faceted aspect has been made whose line thickness has been changed like a pond in Figure 12.

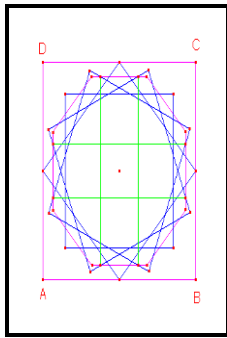


Figure 11

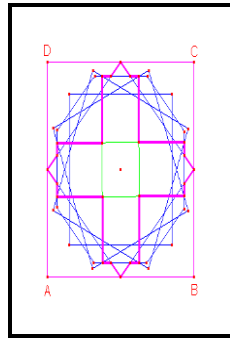


Figure 12

Polygon on Figure 12 rotates as far as 45° so that it looks like Figure 13. Furthermore, the lines and dots that are not needed are hidden by the Hide/Show tool and with a few modifications, ornament was finish. Products in this process are shown in Figure 14.

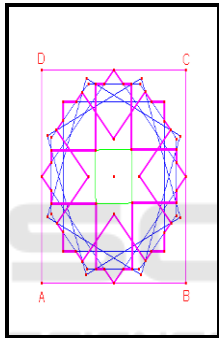


Figure 13.

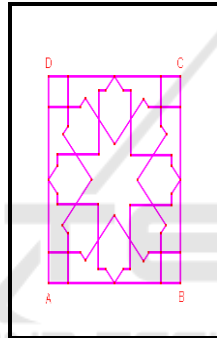


Figure 14.

2.2.4 Wall Ornaments II

The following wall ornaments are the most complicated ornaments patterns (Figure 15). In general, this pattern has a ten-sided star in the middle of the ornament and a five-sided star on the edge of the ornament as a result of the pattern of lines formed. One way drawing these ornaments is as follows. The first, drawing the square and irregular pentagon in it with the Regular Polygon tool. Then the regular pentagon formed is rotated as far as 18° with the center of the rotation angle in the middle of the lot as shown in Figure 16.



Figure 15.

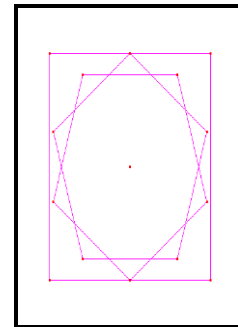


Figure 16.

The next step is to divide the right and left sides of the square into four equal parts with the Midpoint tool. After that, draw two parallel lines as shown in Figure 17 which will be used as the initial pattern. The two lines are then rotated one by one as far as 36° four times with the Rotation and Numerical Edit tool with the rotating axis in the middle of the polygon. The results of the rotation can be seen in Figure 18.

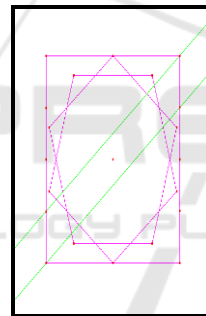


Figure 17.

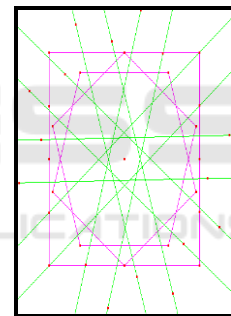


Figure 18.

The color of the two pentagons in the center of square was converted. The goal is only to distinguish the many facets of color that will be made later. After that, many facets are made which have thickened the size of the lines that look like Figure 19 with the Polygon tool. Then the many facets are rotated as far as 36° with Rotation and Numerical Edit tool with a rotating axis in the middle of many facets and produces Figure 20.

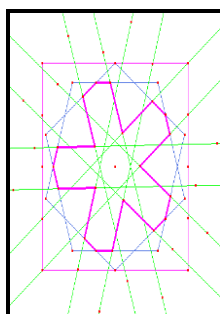


Figure 19.

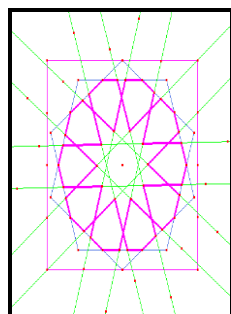


Figure 20.

The next step is to draw five-sided stars that are outside the two many facets that have been made before. In this process, Segment and Ray The tool is used to create the star details that are meant by the choice of thickened green. The results of this process can be seen in Figure 21. After that, lines and points that are not needed are hidden with Hide/Show tool. The final result of this process is shown in Figure 22.

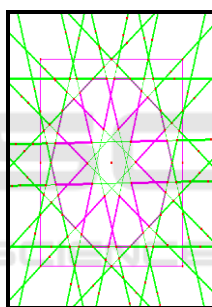


Figure 21.

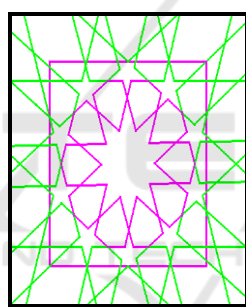
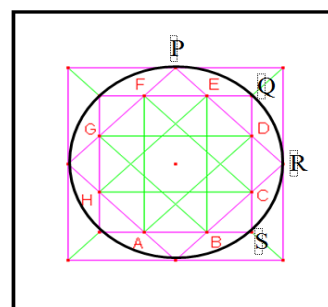


Figure 22.

2.2.5 Using Ornament to Proof Geometric Properties

We have created Figure 6 with interactive geometry software. To teach student who to proof geometry properties, we can create a task to students to prove that $FC \parallel GB$. To prove that $FC \parallel GB$ we need to construct a cycle through P and the center in the center of square.



$\angle SQR = \angle PRQ$ (inscribed angles subtend equal arcs)
 $\Rightarrow \triangle QDR$ is an isosceles triangle
 $\Rightarrow DQ = DR$.
 $\triangle QDE \cong \triangle RCD$
 (because $\angle EQD = \angle DRC = 90^\circ$)
 $DQ = DR$ dan $\angle EDQ = \angle CDR$
 (vertical angles)
 Similarly, we get:
 $SC = CR = RD = DQ = EP = PF = \dots$
 $\Rightarrow CD = DE = EF = \dots$
 In the $\triangle FQC$, $QE = QD$, $EF = DC$
 $\Rightarrow ED \parallel FC$. Similarly, $HA \parallel GB$. from $HA \parallel ED$,
 It follows that $FC \parallel GB$.

3 CONCLUSION

Ornaments that have been created in the discussion were a small part of the geometric patterns that can be found in everyday life. The use of these ornaments in learning mathematics, especially geometry is still very possible. Geometric patterns or ornaments that there can actually be used as a source of learning mathematics will be full of creativity for students who learn by means of the ornaments will be more active and increased interest in the material being taught (Suratno, Ardiana and Tonra, 2018). In addition, learning with ornaments media will enhance students' creativity in making new ornaments as well as looking for a variety of new ornaments that one with access it via the Internet. Teacher can use ornament to teach students about proving. Similar studies related to geometric ornaments both derived from Islamic culture or other religions are still very open. Our next task is to study and design a form of learning activities by utilizing the results.

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