EFFICIENCY OF THE DYNAMIC GEOMETRY SOFTWARE FOR SELF-EDUCATION ON ONE GEOMETRIC CONCEPT

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Abstract

The paper deals with the research project concerning the efficiency of GeoGebra for self-education on the geometric concept regular tessellations to compare with the traditional methods (paper and pencil or using paper models). The project was provided on the sample of more than 70 students of non-mathematics bachelor studies. Our results point that GeoGebra (i.e. Dynamic Geometry Software) does not have to be all the time better than traditional methods, especially if it is used exclusively for self-education.

Keywords: regular polygons, regular tessellations, dynamic geometry software

EFEKTIVITA SOFTWARU DYNAMICKÉ GEOMETRIE PŘI SAMOSTUDIU NA PŘÍKLADĚ JEDNOHO GEOMETRICKÉHO KONCEPTU

Resumé

Článek prezentuje výzkumný projekt týkající se efektivity využití programu GeoGebra při samostudiu realizovaného na základě geometrického principu pravidelných teselací v porovnání s tradičními metodami (tužkou na papír či použitím papírových modelů). Projekt byl realizován na vzorku více než 70 studentů nematematických bakalářských studijních oborů. Naše výsledky ukazují, že použití programu GeoGebra (příklad softwaru dynamické geometrie) nemusí být vždy lepší než tradiční metody, zejména pokud se používá výlučně pro samostudium.

Klíčová slova: pravidelné mnohoúhelníky, pravidelné teselace, software dynamické geometrie

1 Dynamic Geometry Software

According to the even relatively old bibliography (e.g. Clements and Battista, 1992), the results show that Dynamic Geometry Software is rather efficient in the learning of geometry. The learning of geometrical concepts would be made easier by the fact that the constructions take place in a direct way; users' actions are based upon formal geometrical aspects. There is a question here, however: Is Dynamic Geometry Software panacea, i.e. is Dynamic Geometry Software something that will solve all problems (in Geometry)?

However, the actual trend in education known as Inquiry-based education offers especially in geometry space for inquiry and discovery. The situation is enhanced by the potential of dynamic geometry software that are especially suitable for inquiry and experimentation. (e.g. Nocar - Novák, 2015; Nocar - Zdráhal, 2015).

2 Problems concerning Regular Tessellations

We made the research concerning the relation among the use of traditional method (students' work with textbooks), enhanced traditional methods (using of so called Material Cards) and GeoGebra Dynamic Geometry Software, respectively for self-education on the geometric concept regular tessellations. In total 76 freshman students of the bachelor studies at the Purkyně University in Ustí nad Labem, Czech Republic were tested. We wanted to know, if they were able to explain why some regular polygons tessellate. It was the first time when the students met the concept regular tessellations. On the other hand all students had in the past the opportunity to work with the software GeoGebra.

Students were acquainted with the concept regular tessellation only by the definition saying that if a (regular) figure can be used repeatedly to cover a surface without gaps or overlaps, is said to tessellate the surface and the resulting pattern is called a (regular) tessellation.

Then the questions as follows were given to students:

- Which regular polygons in the presented figure (see below the Image 1) will tessellate and which will not tessellate?
- What conditions have the angles of regular polygons satisfy in order for the polygons to tessellate?

Students were randomly divided into three groups. Students in the first group were provided with the figures of regular polygons drawn in the standard textbook. Students in the second group were provided with the Material Cards (just figures of regular polygons - they could manipulate with them immediately). Students in the third group were provided with the tablets and Geogebra Dynamic Geometry Software. Once a student found the solution of both questions, her time in minutes was measured; the maximum given time was 45 minutes - all students found the solutions sooner, however (and all solutions were correct).

Time (in minutes) needed for students to solve the problem was measured, see below the Table 1. The left upper corner number 15 in the column "Textbook" means time in minutes for the first student among them who were trying to solve the problem on the basis of the figures in the textbook. The second and the third columns give time for students solving the problems by means of Material Cards and GeoGebra, respectively.

We wanted to find out if there is any significant difference among these three methods for the proper understanding of the concept regular tessellations. So we used a single factor ANOVA in Excel to test the null hypothesis that the time means of these three populations (students provided with Textbook's figures, students provided with Material Cards and students provided with GeoGebra program) are all equal.

H_0: $\mu_1 = \mu_2 = \mu_3$

H_1: At least one of the means is different.

Regular polygons from the first question look like this:

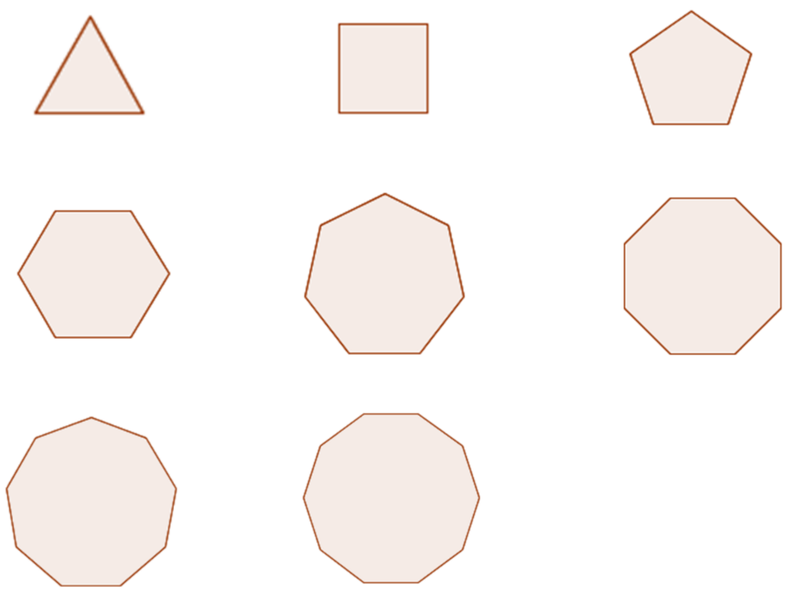

Image 1 - Figures in the Textbook: Regular Polygons & Material Cards: Polygons for Regular Tessellations

Students from both the group 1 and the group 2 worked only with these polygons - group 1 students (Textbook group) used only figures drawn on the paper, students from the group 2 (Cards group) could manipulate with figures' models.

Students from the group 3 (GeoGebra group) could use all tools of this software; there is their procedure in the following Images 2 - 8.

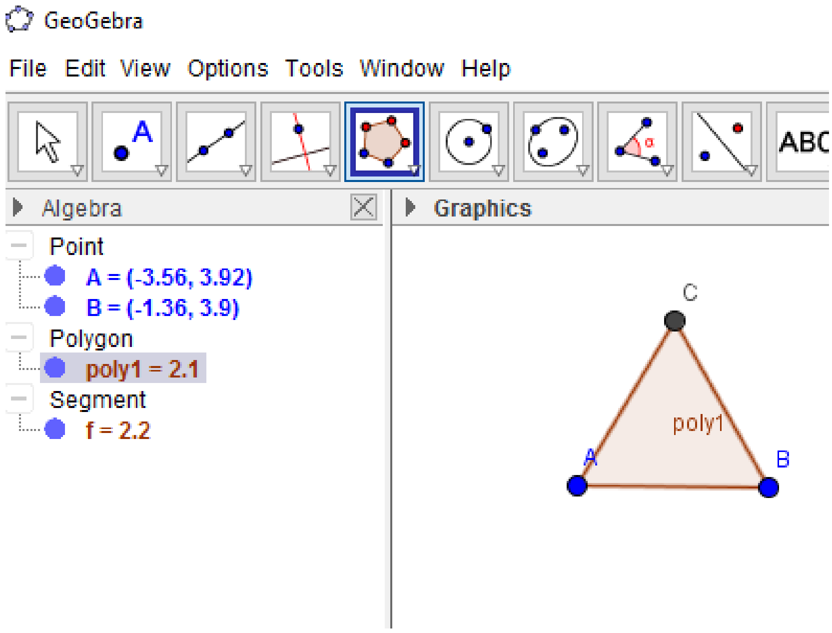

Image 2 - Equilateral triangle in the GeoGebra

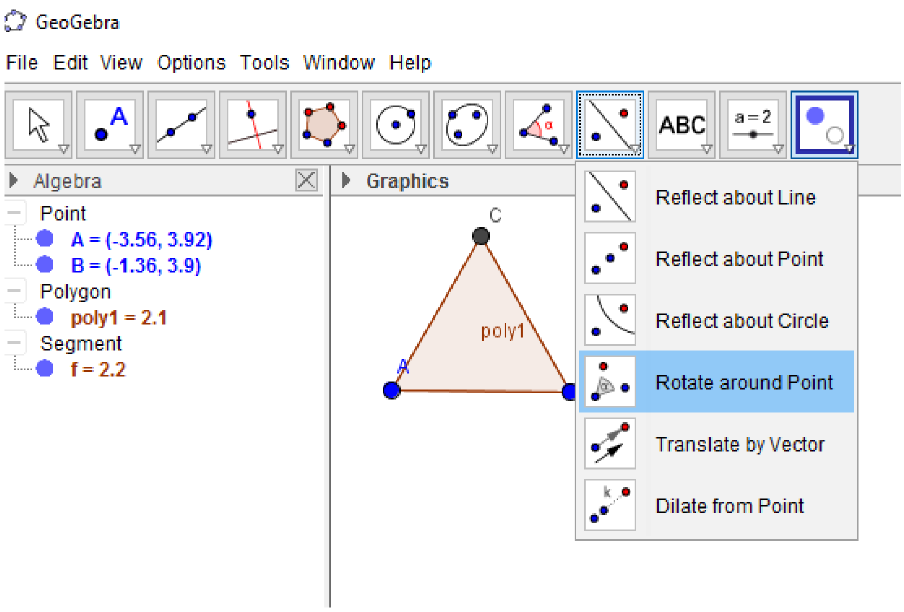

Image 3 - Equilateral triangle rotated around the point

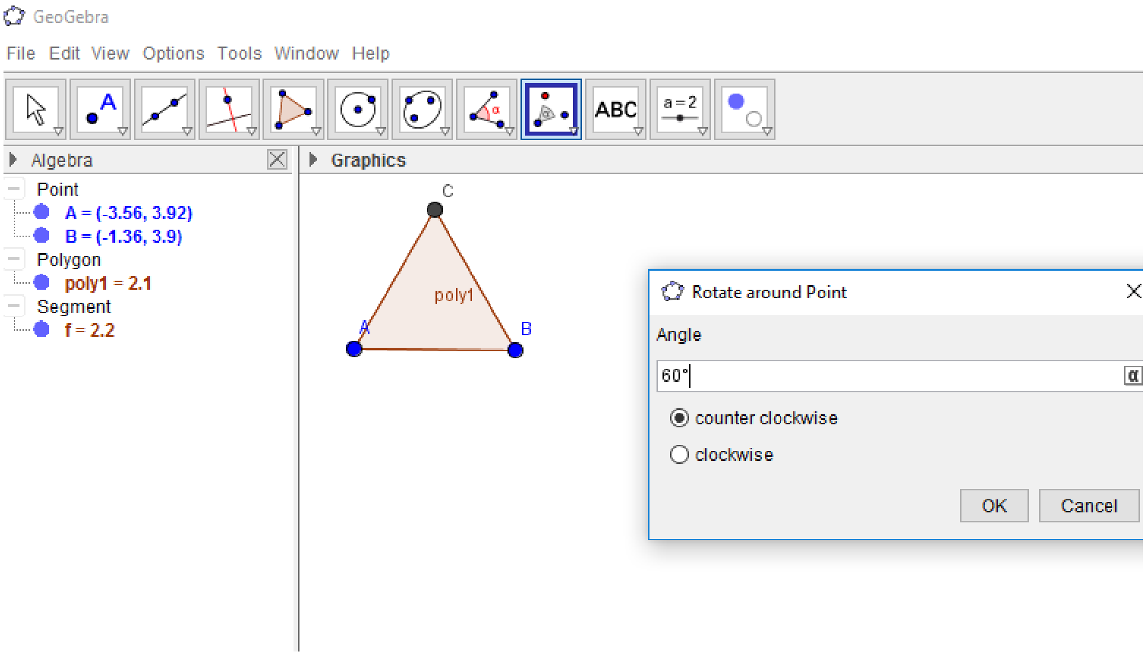

Image 4 - Equilateral triangle rotated around the point at 60°

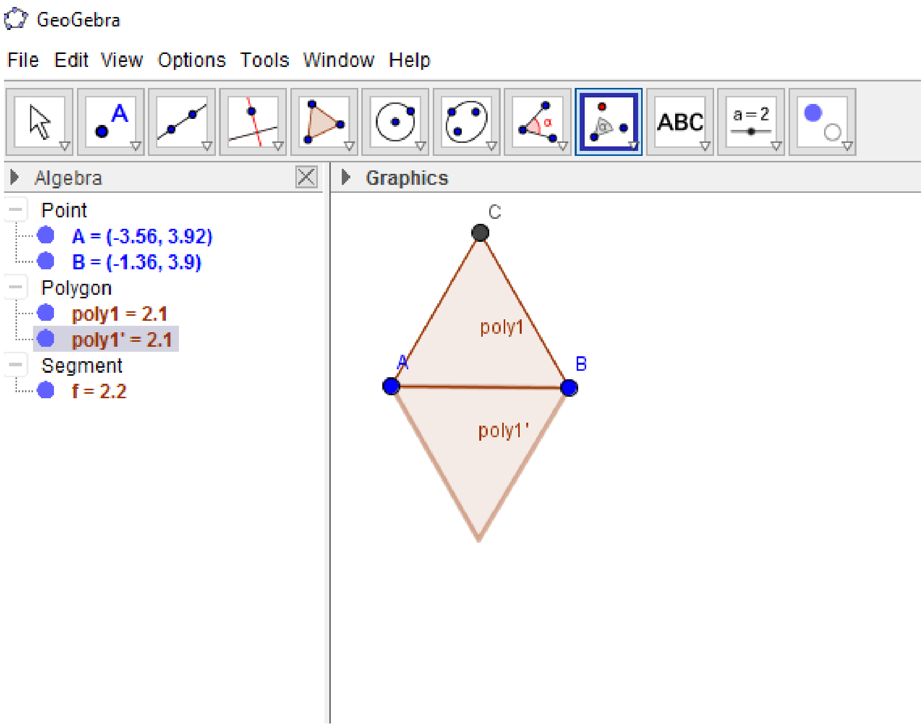

Image 5 - Tessellation starts

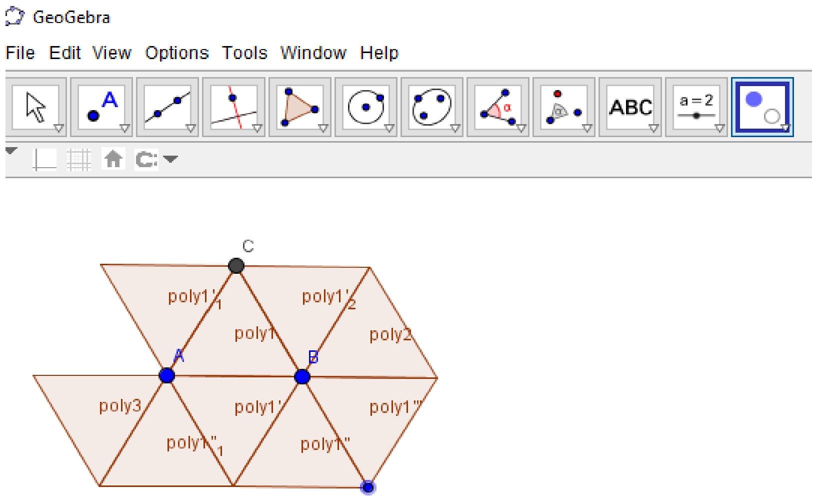

Image 6 - Tessellation continues

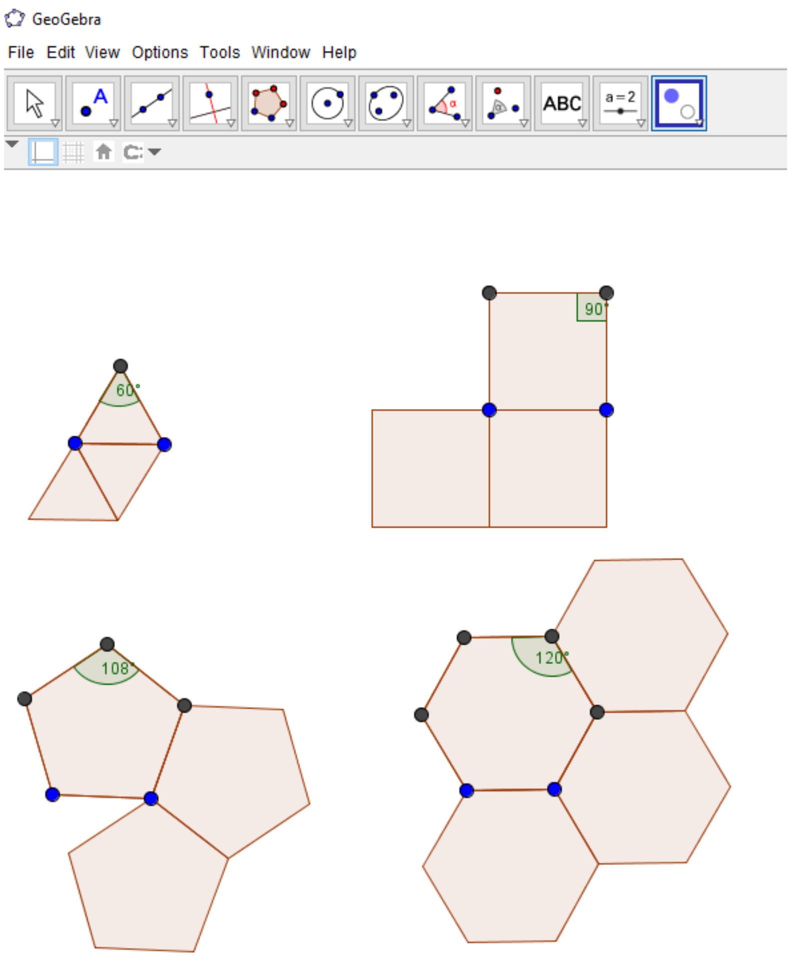

Image 7 - Trying to make Tessellations 1

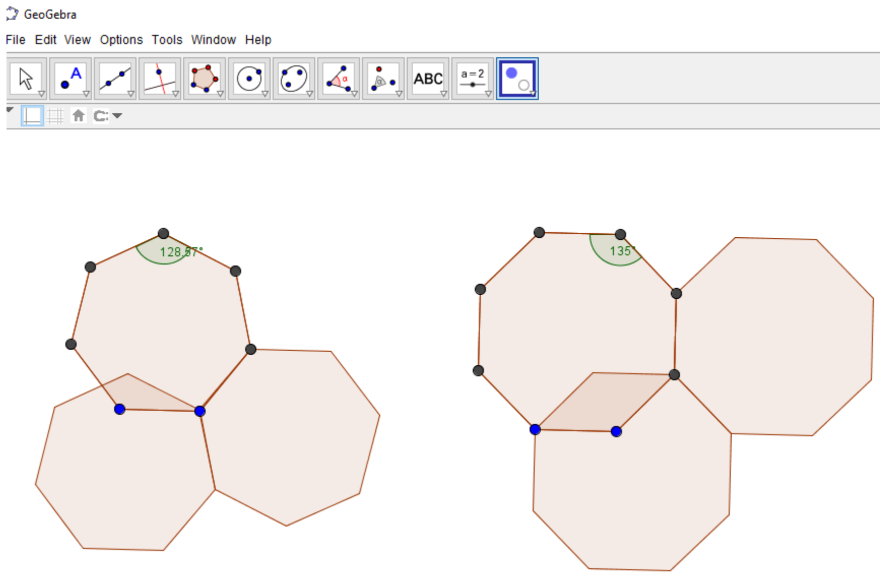

Image 8 - Trying to make Tessellations 2

Single Factor Anova method was used to test the null hypothesis that the time means of these three populations (Textbook, Cards and GeoGebra) are all equal.

Table 1: Anova: Single Factor from excel

	A	B	C	D	E	F	G	H	I	J
1	Textbook	Cards	Geogebra	Anova: Single Factor						
2	15	16	9							
3	12	15	12	SUMMARY						
4	18	12	10	*Groups*	*Count*	*Sum*	*Average*	*Variance*		
5	15	10	11	Column 1	27	394	14,59259	34,40456		
6	10	19	12	Column 2	25	321	12,84	9,39		
7	12	10	10	Column 3	24	312	13	12,17391		
8	19	16	14							
9	31	11	13							
10	32	12	19	ANOVA						
11	12	10	18	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
12	10	14	15	Between Groups	49,10832359	2	24,55416	1,280435	0,284083	3,122103
13	19	13	10	Within Groups	1399,878519	73	19,17642			
14	10	10	12							
15	16	12	19	Total	1448,986842	75				
16	11	19	10							
17	12	16	19							
18	10	11	10							
19	10	12	16							
20	12	10	12							
21	19	19	10							
22	10	10	19							
23	12	12	10							
24	19	10	12							
25	10	10	10							
26	10	12								
27	16									
28	12									

As we can see from the above Table 1, $F < F\ crit$, it means we cannot reject the null hypothesis that all means are equal.

Conclusion

The result of the presented research project did not show that, as for the self-education of the concept regular tessellations, the efficiency of the Dynamic Geometry Software was very high - we cannot say that there were significant differences among used methods (traditional versus new one, supported by ICT).

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