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Investigation the Geometric Thinking of Nine Graders'

Veronika Bočková and Gabriela Pavlovičová

Constantine the Philosopher University in Nitra, Faculty of Natural Sciences, Department of Mathematics, Nitra, Slovakia; veronika.bockova@ukf.sk, gpavlovicova@ukf.sk

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Geometry is one of the most important topics of mathematics education. Even though most pupils just see geometry as the study of objects, points, shapes, geometry, is also applied in other subjects such as engineering, architecture or music. For these reasons, a very important teachers' role is to arouse pupils' interest in geometry and create a positive relationship with it. Sometimes it is a challenging mission because as we can observe in recent years, students in Slovakia achieve a relatively low level of geometric knowledge (Bočková, Pavlovičová, Čeretková, 2020). The pupils' problems with geometry can be caused by the fact that pupils are at a very low level of geometric thinking or mathematics competencies in geometry. For this reason, it is very important to use van Hiele theory at all levels of education.

Dutch mathematicians Pierre van Hiele and Dina van Hiele – Geldof tried to understand and eliminate pupils' problems in geometry. Based on their observations, they described the model of geometric thinking in 1957. Van Hiele theory consists of five hierarchical and sequence levels (visualization, analysis, informal deduction, formal deduction, rigor) (Usiskin, 1982; Van Hiele, 1986). Today, van Hiele model of geometric thinking forms the basis of the content of education in various countries, such as the United States, Russia, Netherlands and Taiwan.

The main aim of this poster is to present the research about geometric thinking and mathematics competencies in the geometry of nine-grade pupils in Slovakia, who finished the lower middle school level of education. The research is focused on determining the level of geometric thinking of pupils. The aim of the research is a quantitative evaluation of the solution of geometric problems, too. We also would like to find out the connection between the correct solutions of the geometric problem at different levels of mathematics competencies in geometry and the level of geometric thinking according to Van Hiele theory.

The levels of pupils' geometric thinking were determined by using the van Hiele geometric test. The test was applied with the consent of Professor Zelman Usiskin. We suggested the valid and reliable Test of mathematical competencies in geometry, too. In the test, we used PISA division of mathematical competencies into three competency clusters: reproduction, connection and reflection. The test contains three tasks for each of the three levels of mathematical competencies. The research was realized in May – June 2021. The research sample consisted of 760 nine-grade pupils, who solved the van Hiele geometric test and Test of mathematical competencies in geometry.

According to Mc Anelly (2011), who has stated the separated levels of geometric thinking in the age category, pupils in the second stage of elementary schools should be at the level of analysis or informal deduction. Our research shows that 50.5 % of pupils achieved the required level of analysis or a higher level of geometric thinking (21.3 % - analysis level, 24.2 % - informal deduction level, 5 % - formal deduction level). The surprising finding is that 7.4 % of pupils did not even reach the level of visualization and 27.5 % of pupils achieved the

visualization level. 14.6 % of pupils did not assign any level of geometric thinking. We compared same-age pupils from other countries with similar research, which was carried out by Usiskin (1982), Haviger, Vojkůvková (2013), Adelabu, Makgato, Ramaligela (2019) and Idris (2009). Slovak students have a similar or higher level of geometric thinking.

From the solution of geometric problems at different levels of mathematical competencies, it follows that pupils have a lot of misconceptions of basic knowledge in geometry. They cannot identify or use the formula for geometric shapes. They do not determine the length of the sides and the length of the altitude of geometric shapes from the picture, they have problems read from the image. Pupils also use the Pythagorean theorem in the general triangle and they have an incorrect conception of a straight angle.

We used statistical implicative analysis methods, specifically C.H.I.C. statistical software (Classification Hiérarchique Implicative et Cohésitive) to compare and reveal the connections between the level of mathematics competencies with the attained level of geometric thinking according to Van Hiele theory. An important finding is that we confirmed the interconnection between the solutions of individual tasks of both tests, with the achieved level of geometric thinking as well as with the correct solutions of tasks at a certain level of competence.

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