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# THE DEVELOPMENT OF THE CONCEPTS ABOUT SIMILARITY AND RATIO IN MATHEMATICS EDUCATION

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**ABSTRACT**. *In our article we focus on the connections between some topics of mathematical curriculum at all level of primary and secondary school. These topics are similarity, homothety, ration and fractions. We mention about the motivation and the creativity in problem posing process as an important aspect of education. The creation of the tasks which are connected with one picture on different level of education is presented as an example of mentioned processes. We used a photo of geometrical garden as a motivation tool. We wanted to show one of the possible approach, how to use real life object for the creation of the geometrical problems in various levels of difficulty.*

**KEY WORDS:** *ratio, similarity, geometrical task, education*

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## Introduction

A subject matter like similarity is one part of the mathematical education since the primary school level to secondary one. The process of enlargement and reduction of geometrical shapes and figures begins as a square grid tasks and continues using the homothety. There is a strong connection among the similarity as the geometric topic; and ratio and fractions as the arithmetic topic in the school mathematical education.

As is mentioned in [1] the interdependence of these topics and the relationship among different parts of the mathematics (the arithmetic, geometry and algebra). The author pays an attention to the fact, that the geometrical and the numerical context are interlinked. Also notes that many topics follow each other without the reminder and this fact if often omitted in school praxis. The author compared mathematical topics starting the number comparisons through the fractions and the ratios to the proportions. The author defines the $k$ factor to define the Identity, the Similarity and the Homothety.

In next sections we focus on three areas:

- the similarity, homothety, ratio and fractions in the mathematical education at primary and secondary school,
- the motivation and the creativity in the problem posing process,
- creation of the tasks connected with a picture on different level of education.

### The similarity and the ratio in the mathematical school education

According to The National Educational Program in Slovakia pupils meet with propaedeutic of fractions and similarities already at the primary level of education. As is stated in [2], pupils should acquire concepts as a whole, part of a whole, the number of equal parts (the division), the group size (after division) and have the ability to divide a whole into equal parts, to divide according to content. The curriculum of geometry of the

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primary and lower secondary education included topics such are enlarging and reduction of geometrical shapes in a square grid which is connected with the ratio. The curriculum according to [3] includes the topics: ratio; to divide unit in a given ratio; plan and map scale; continual and reciprocal proportion; simple rule of tree (plicate too); utilization of continual proportion in practice (contextual and stimulative tasks). Pupils are working with similarity in the topics: similarity; similarity of triangles; similarity of geometric figures; ratio of similarity; division of the segment in a given ratio; solution of a mathematical (numerical) and constructions tasks; utilization of similarity by measuring of heights and distances; topographic works in the real situation. This part of geometry is developed at the higher level of secondary education according to [4] in the topics: practice mathematics – map and plan scales; basic geometric figures; geometric points of places (constructions); measuring; estimating; geometry of acute angle; identity; similarity. According to the performance standards in this domain, the student should know: use the rule of three; use the continual and reciprocal proportion to solve simple practical problems; construct in simple cases the basic planar figures; use right triangle geometry to calculate the size of angles and lengths of sides; to solve applications tasks by using trigonometry; determine similarity of the triangles; apply the relationship between similar triangles to solve geometric problems; deduce Pythagorean Theorem and Euclid sentences; count the length and distance by using these sentences; determine the approximate dimensions of unavailable services by using similarity.

**The motivation and the creativity in the problem posing process**

Mathematics is an integral part of the real-life not only for many daily activities but also for a wide variety of work situations. It is necessary to transfer the math knowledge and skills gained in schools to the real-life that require the individual to reason, calculate, estimate or apply math knowledge to solve real-life problems and also to communicate mathematically [5].

There are a lot of objects in our ordinary life which could be used for creation challenging learning environment and develop pupils and also teacher´s creativity in mathematics. As is in [6] described, mathematical creativity as an ability to analyze a given problem from a different perspective, see patterns, differences and similarities, generate multiple ideas and choose a proper method to deal with unfamiliar mathematical situations.

According to survey [7], creativity of children in great deal depends on the teacher's approach. When pupils solve only standard tasks by using always the same methods, they have problems to change their learning way or create a task independently. Children can develop certain commodity in thinking, little initiative or even unwillingness to work.

Creativity in the mathematics classroom is not just about what pupils do but also about what we do as teachers. If we think creatively about mathematical experiences that we offer our pupils, we can open up opportunities for them to be creative [8]. Creative teaching requires from teacher to create and exercise such tasks, which would enable pupils to use their acquired knowledge more freely, in new contexts and when solving new and unknown problems [9].

Motivation and creativity in the geometrical problem posing process is processed in the work of several authors, for instance [10], [11], [12], [13].

**The Similarity and the Homothety in the tasks**

We will show the way how to use one picture for the creation of geometrical problems at various levels of education. We apply graded approach and present the tasks based on the school curriculum and with real live context. The motivation was found in the nice geometrical gardens (Fig.1) and we used the photo for drawing elementary pattern in the square grid (Fig. 2).

Fig. 1: The geometric patterns in Anguri Bagh garden, Agra Fort. Agra in India.

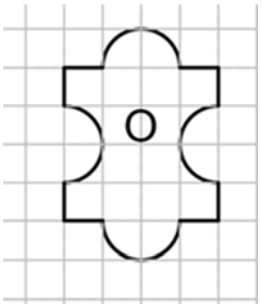


Fig. 2: The geometric patterns O in the square grid

**Task at the primary school level**

Primary school pupils should solve the task given in the square grid, to draw the pattern which will be two times bigger. We will use twice the size unit of a square grid and pupils can only retrace individual lines in one square. Result will be two times increased pattern $O_1$. Pupils can draw or use the drawing tools: the ruler and the compasses.

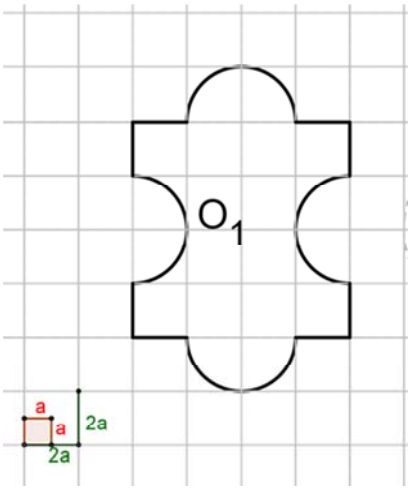


Figure 3: Solution in the twice the size square grid

**Task at the lower secondary school level**

At the lower secondary school level we can solve the previous task, but in the same square grid (the same unit square). Pupils have to pay attention to the individual elements

in the pattern and each of them draw twice as large. It is important to determine the center and the radius of a circle (Fig. 4).

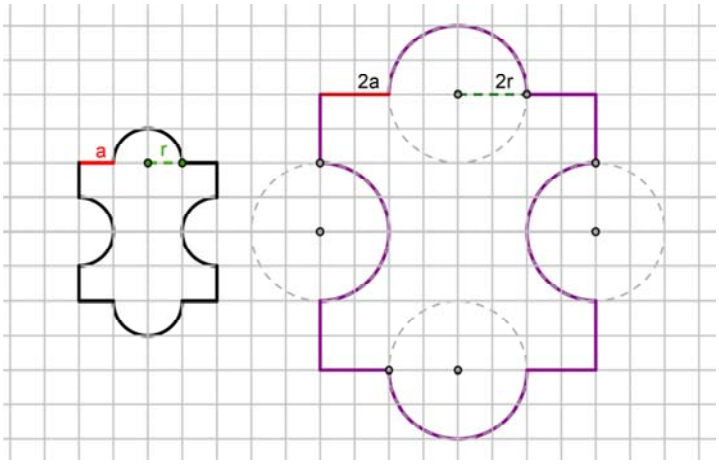


Figure 4: The solution in the same square grid

**Task at the higher secondary school level**

At the higher secondary school level we can use the homothety with scale factor *k* equals 2. We can also create opposite task, to find a center and a scale factor of the enlargement that will transform a pattern O onto a pattern $O_2$ (Fig. 5)

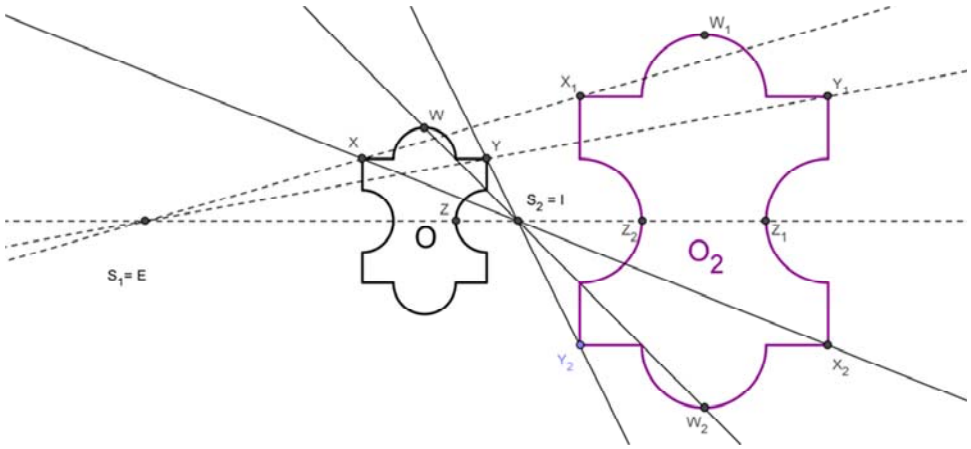


Figure 5: Application of homothety

Every mentioned geometrical problem is connected with using the ratio. We can construct, for example, tree times bigger figure and then two times smaller figure and search a similarity ratio between first and third figure. We can create a word geometrical tasks with various context to all of previous examples. The pupils can work in a role as a garden architects or a puzzle creator, can construct the same pattern in different sizes, create wall or floor tiles, do a patchwork and so on. Work with non-typical geometric shapes could be more demanding for analyzing of the individual shape elements, precision,

patience, construction, but good motivation and connection with real life objects can diversify mathematics education.

## Conclusion

The development of children's perception of geometrical concepts is related with the environment where early age children are brought up and gain everlasting and informal knowledge. It is important to combine the knowledge with real life situations and to find motivation for pupil´s work at school. In our article, we wanted to show one of the possible approach, how to use real life object for the creation of the geometrical problems in various levels of difficulty. Most of the common school mathematical tasks are focused on the acquiring of expected knowledge by solving the routine tasks. The motivation and the creativity are very important aspects of education. According to the feedback from the pupils at lower secondary school after solving presented tasks, it was not easy but interesting work.

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