Acta Didactica Napocensia

Volume 8, Number 1, 2015

# Creativity and Motivation for Geometric Tasks Designing in Education

**Lucia Rumanová, Edita Smiešková**

**Abstract:** In this paper we focus on creativity needed for geometric tasks designing, visualization of geometric problems and use of ICT. We present some examples of various problems related to tessellations. Altogether 21 students – pre-service teachers participated in our activity within a geometry course at CPU in Nitra, Slovakia. Our attempt was to familiarize pre-service teachers with different teaching methods and approaches since we consider it highly important to make them aware of problems of educational process. Students became familiar with tessellation and within the described activity they solved application tasks using didactical software GeoGebra. Tessellation is considered an appropriate means of motivation and activation of students in mathematics. In the paper there are also students' solutions presented.

**Key words:** activity, students, tessellation, tasks designing, ICT

**Code from 2010 MSC:** D45, U75

## 1. Introduction

In the past educational process was understood as a unilateral action of the teacher to pupils, resulting in formation of new knowledge, skills and behavior of students. However, educational process is nowadays considered an interaction of several factors – the curriculum, the educational environment, the teacher and the student. Both the teacher and the student are the main actors of the educational process. The role of the teacher is to teach and the role of the student is to learn actively. In educational process these two factors interact, adapt and cooperate. In other words, the student is not only the object of the teacher's action, but also the subject of the process, because students live out this process, also express their attitudes and operate retroactively to the teacher's methods [1].

Mathematics as a school subject informs pupils of abstract system of knowledge. It is useful to make this system closer to pupils by using hands-on objects and activities which they have already had certain experience with. Pupils gain the ability to use mathematics by being directly involved in the world surrounding them. Inter-relating the knowledge gained in the educational process with reality gives pupils greater motivation to continue learning and gaining further information this way [2].

In the paper we focus on creativity, geometric tasks designing, and computer visualization of the solutions to the tasks with the use of didactical software. The similar problem is presented in paper [3] where the tilling designs are built using web-based system TilerPro.

## 2. Theoretical background

Creativity in mathematics classrooms 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 to our pupils, we can open up opportunities for them to be creative [4].

Creativity of children depends to a considerable extent on the teacher's approach. When pupils solve only traditional tasks always using the same methods, later on they might have problems to change

*Received February 2015.*

their learned way or create a task independently. Children can develop certain commodity in thinking, little initiative or even unwillingness to work [5].

In terms of school educational process, creativity is mainly being developed when creative activity of students is intentionally induced, when students are motivated to be creative (especially by being put into such situations and being asked to solve such tasks which require their creative and strategic thinking), but when students are situated in an appropriate creativity-promoting social climate. The main means of motivation in activities of students are the learning tasks and also the teacher who constantly motivates students to work independently, actively and creatively. Motivation is the awakening of students' interest in learning, in what we want to achieve in lessons. If motivation is properly chosen, then it is very important because it facilitates the teacher‘s work with students. The most important factor in the educational process is therefore the teacher's personality [6].

We analysed activity which was realized with pre-service mathematics teachers. They can use the activity to increase creativity and motivation of pupils in their own school practice. Our objective was to familiarize the pre-service teachers with different teaching methods and approaches since it is necessary to make them aware of problems of educational process.

## 3. Methodology

In educational process it is necessary to maintain coherence of newly acquired knowledge with real life in order to gain permanent and non-formal knowledge of students. This can be secured by implementation of geometric application tasks which develop pupils' independence, activity and creativity, starting at the lowest grades of elementary school. By solving such application tasks students should become able to formulate problems, obtain the information needed to solve the tasks, deal with the tasks in context, express their opinions, and propose conclusions implied by the tasks solutions. When solving geometric problems it is useful to visualize them with the use of ICT. For this purpose we used software GeoGebra.

To provide support for the described facts we prepared an activity for pre-service mathematics teachers in a geometry course at CPU in Nitra. The content of this course is primarily focused on geometry of identity and similarity. Students study properties of planar congruent transformations in detail and apply their acquired knowledge in solutions of constructional tasks.

The main objective of the activity was to analyze the relationship between:

- relatedness of geometric knowledge to real life,
- computer visualization with didactical software,
- improving skills at using GeoGebra,
- motivation for further study of tessellations,
- motivation to design geometric tasks,
- creativity in educational process.

After realization of the activity students completed a short questionnaire and discussed the given issue. The questionnaire included five statements related to the conduct of activities and students therein expressed the level of their agreement with the statements.

The activity was designed in accordance with mathematical competencies in terms of which students should become able to:

- apply mathematical thinking to solve practical problems in everyday situations,
- acquire basic ICT skills as a prerequisite for further development,
- use ICT in educational process,
- critically evaluate information and its source, work in the creative process and practically use of all,
- know goals and priorities to established in accordance with their real abilities, interests and needs,
- innovate routines in tasks solving, plan and manage new projects to achieve their objectives, not only at work, but also in everyday life [7].

## 4. Details of presented activity

The activity was realized in November 2014 within four lessons with 21 students of the Mathematics Teacher Training Study Programme.

In the first lesson we discussed tessellations with students, whether they knew them and where they can encounter them and so on. An interesting finding was that the notion of tessellation was a new one for students. Only two students were familiar with the notion of tessellation, and they were not able to explain its sense. Then, we explicitly defined tessellations. In Figure 1 there are examples of three tessellation possibilities when the polygon is an equilateral triangle, a square, or a regular hexagon [8].

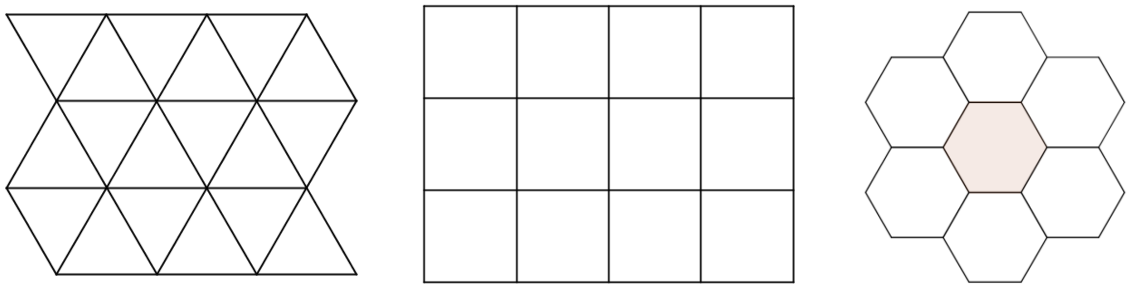

**Figure 1.** *Examples of tessellation possibilities*

The discussion was still running without any illustrations of tessellations, and we asked the students where they could encounter tessellations in their everyday life. After that we talked about possible tessellations, about regular, irregular, triangular and quadrangular tessellations. We aimed to motivate students with the use of sample tessellations in arts, particularly in the work of the famous Dutch graphic artist Escher (see Figure 2). More about the author can be found in [9].

We can also see tessellations just about every day of lives for example: checketboard, brick wall, honeycomb design [10].

**Figure 2.** *Samples of tessellations in arts*

They could apply their knowledge in the task where they were asked to draw triangular tessellations in GeoGebra. We talked about the process in GeoGebra and tried to find the simplest way to create triangular tessellations. Those days, students were acquiring basic skills with GeoGebra as a part of the subject curriculum and they had not known GeoGebra before. Students found various ways of solving the task. At the end they agreed to use rotation and reflection, they also suggested using translation. There are examples of their solutions in Figure 3.

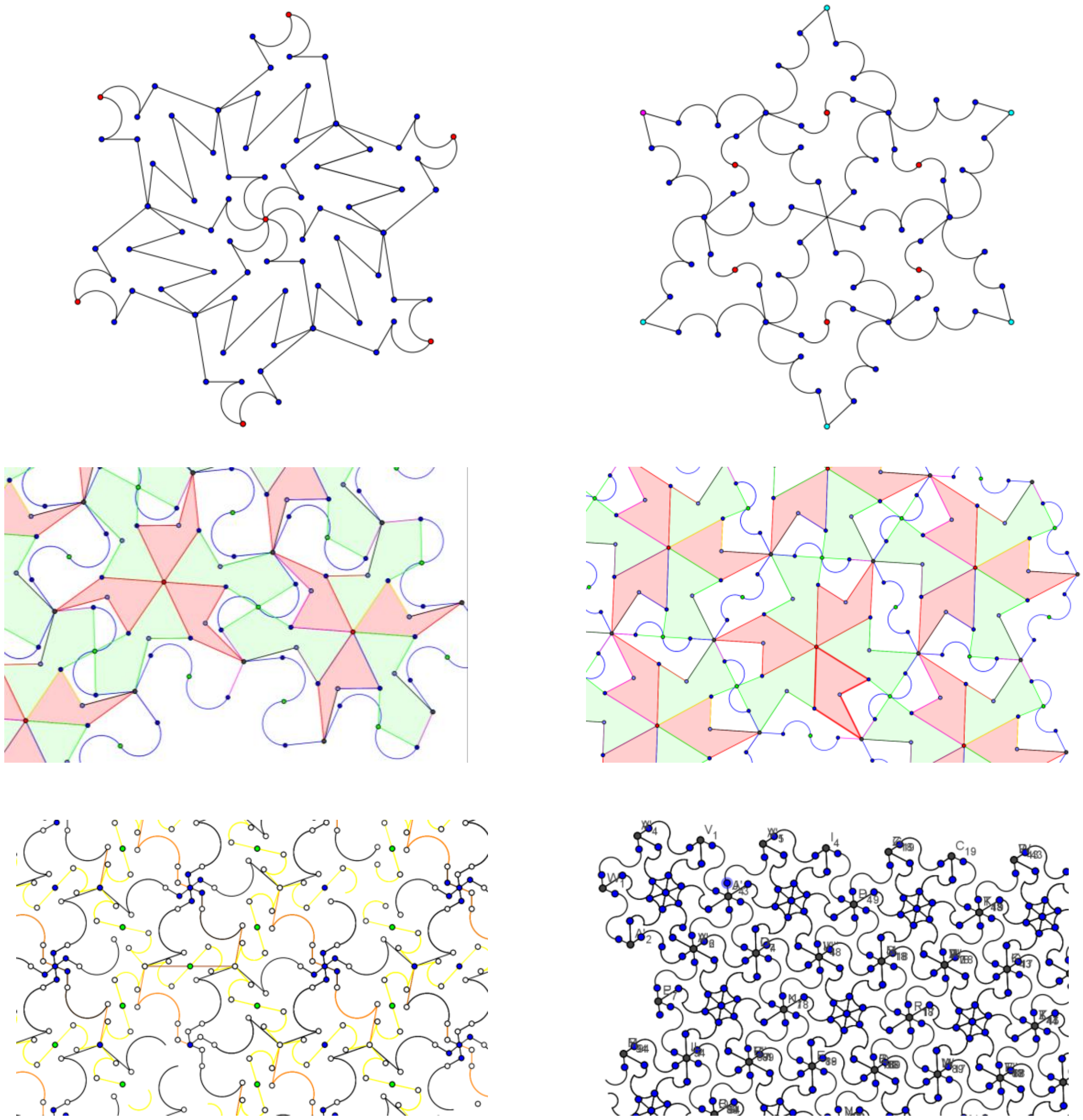

**Figure 3.** *Examples of students solutions in GeoGebra*

At beginning of the second lesson we revised orally what students remembered about tessellations. Then we discussed irregular pentagonal tessellations (see Figure 4), and in order to raise their interest in tessellations we showed them Penrose mosaic (see Figure 5) which might inspire them to study the issue in more detail. There is only one way to fill the plane with quintuple symmetry items, and it was first done by Roger Penrose. He came up with tessellation which is composed of two items – two different rhombuses, one with its interior angles sized 36° and 144°, another one with angles sized 72° and 108°. In the mosaic there are various regular pentagons which are composed of rhombuses that were mentioned above. An interesting thing is that the ratio of the number of the “narrow” rhombuses to the number of the “wide” rhombuses is equal to the golden ratio. It can be said that Penrose tessellation has ordering similar to the one which can be observed in crystals [11].

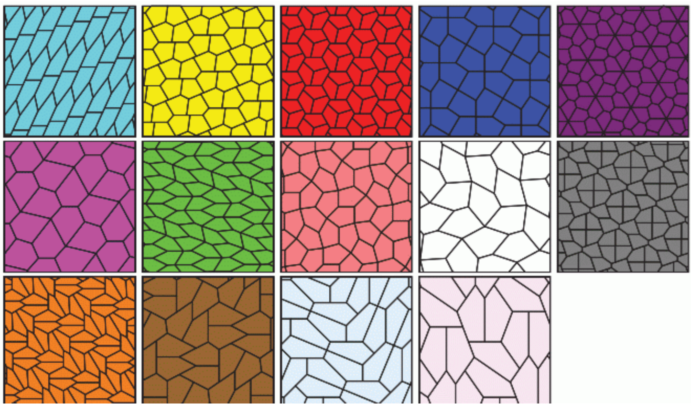

**Figure 4.** *Irregular pentagonal tessellations*

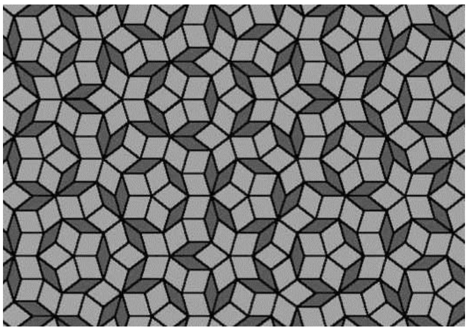

**Figure 5.** *Penrose mosaic*

Since in the lesson there were only pre-service mathematics teachers, the best way to check if students understood tessellations seemed to give them a task where they would practically use tessellations. The task was to design their own task solvable in GeoGebra and inspired by tessellations. After that they had to modify their tasks so that they would be appropriate for primary and secondary school level. Students then orally explained their tasks and presented them, which was recorded with a camera. Below the concrete tasks created by students are presented.

### The task of Student 1 intended for primary school level

Using GeoGebra draw a regular puzzle following this instruction: *Cut* an arc from one side of the square, and then add the same arc on the opposite side. Use *copy* and *paste* button to fill a part of the plane with puzzle pieces. Then, colour your puzzles (see Figure 6).

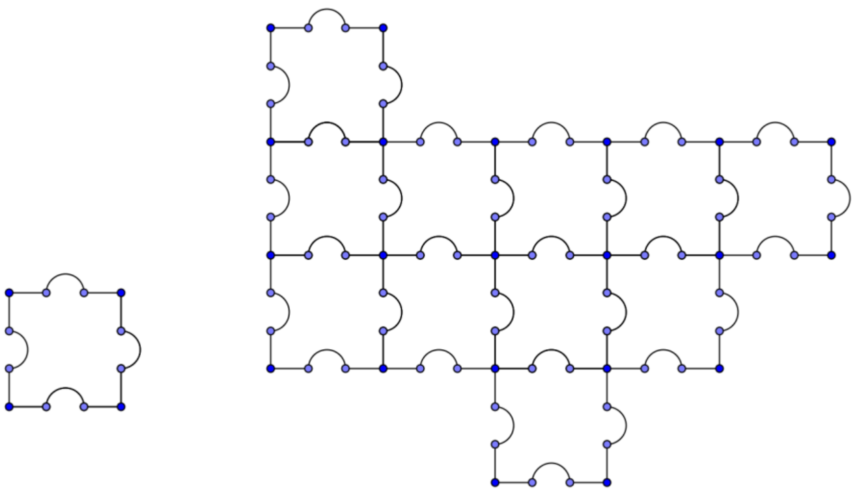

**Figure 6.** *The task of Student 1 intended for primary school level*

### The task of Student 1 intended for secondary school level

In GeoGebra, draw an irregular puzzle using two reflections. Join four irregular puzzles together, and use copy and paste button to fill a part of the plane will the four-part puzzle pieces. Then, colour your puzzles (see Figure 7).

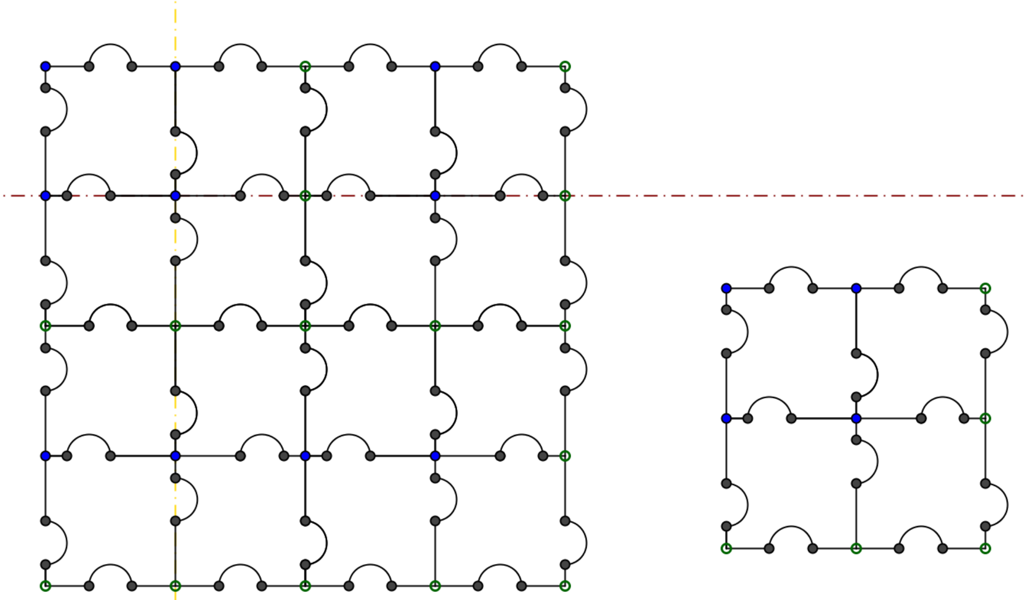

**Figure 7.** *The task of Student 1 intended for secondary school level*

The objectives of the tasks are:
- to motivate pupils,
- to create stress-free atmosphere in the class,
- to develop pupils' creativity,
- to practice basic skills with GeoGebra software,
- to revise gemoterical symmetries.

### The task of Student 2 intended for primary school level

Mr. Novak has bought new tiles into his new house, but he does not know how to compose them. He wants the same pattern as he saw in the shop. Help Mr. Novak to compose the tiles into the same pattern as he saw in the shop. The size of a tile is 50x50 cm, and the room size is 10x6 m (see Figure 8).

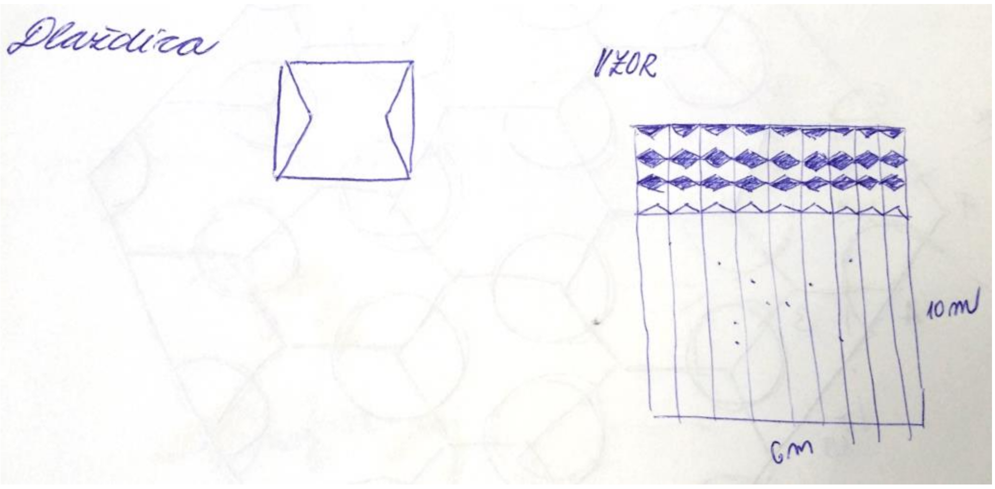


**Figure 8.** *The task of Student 2 intended for primary school level*

The objectives of the task are:

- to practice conversions of length units,
- to practice computation of the surface area of squares and rectangles,
- to revise and practice use of congruent geometric projections (translation, rotation).

**The task of Student 3 intended for primary school level**

Design your own floor pattern. Design the tile unit so that after the tiles are put in a composition, they will create pattern with regular arches and also another complex figure (for example a flower). The student designed an example solution (see Figure 9).

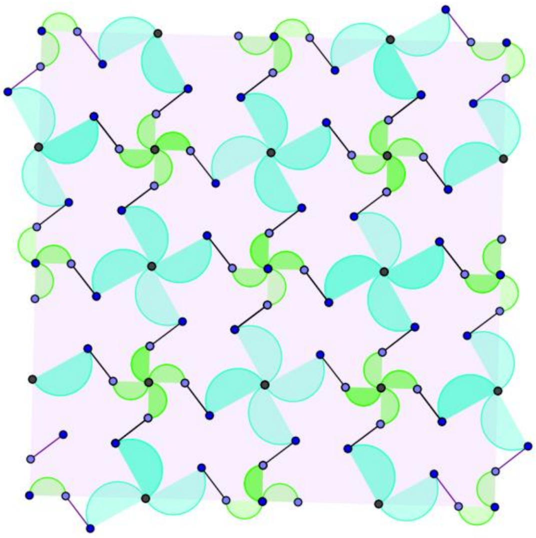

**Figure 9.** *The task of Student 3 intended for primary school level*

The objectives of the task are:

- to practice pupils' perception,
- to improve pupils' imagination,
- to understand relations among items composed in the plane.

## 5. Discussion

Our assumptions from introduction are essentially confirmed. Students state that activity deepened their knowledge of geometry and realized some facts of this problematic. Activity was for them inspiring and beneficial for future math teacher profession. They realized link between specific geometric knowledge and real life. Activity was interesting for them so students tried find more information about tessellation, Escher, etc. Students stated that activity was not difficult, but what was useful for them is visualization of geometric problem using GeoGebra. They also stated that their skills working with GeoGebra after this activity are better (this fact indicates more than half of the students). Introductory activity motivated students further to the creation of geometric problems. Of course there were some weaknesses of students with the formulation of tasks, but nevertheless students created interesting tasks. All students reported that they received the space for their own creative activity, and much they enjoyed such activity in educational process. Students evaluate activity and their work as follows: "I liked the possibility of creative thinking, we could be creative themselves and identify own aims, which supported my creative thinking. For me it certainly inspirations for the future work of teacher." Or "I liked inventing games and activities that I can invent for pupils in the future and also use GeoGebra in solving tasks." We will continue with similar activities in our future work.

## References

[1] http://referaty.atlas.sk/odborne-humanitne/pedagogika/5377/osobnost-ucitela-vo-vyucovacom-procese [16/1/2015]

[2] Pavlovičová, G. (2008), Od číselných predstáv k tvorbe slovných úloh, *DIDZA 5: Nové trendy vo vyučovaní matematiky a informatiky na základných, stredných a vysokých školách*.

[3] Al-Darwish, N. (2012), Creative tiling: a story of 1000-and-1 curves, *Acta Didactica Napocensia*, 5(1), 11 – 16

[4] Švecová, V. – Rumanová, L. (2012), Supporting mathematical creativity in realistic surroundings, *Generalization in mathematics at all educational levels*, Rzeszów, 248-256.

[5] Blažková, R. – Vaňurová, M. (2011), Tvořivost žáku při tvorbě a řešení nestandardních úloh, *Tvořivost v počátečním vyučování matematiky*, Západočeská univerzita v Plzni, 45-50.

[6] http://referaty.aktuality.sk/motivacia-a-osobnost-ucitela-vo-vyucovacom-procese/referat-6203 [18/1/2015]

[7] http://www.statpedu.sk/sk/Statny-vzdelavaci-program/Statny-vzdelavaci-program-pre-gymnaziaISCED-3a/Matematika-a-praca-s-informaciami.alej [18/1/2015]

[8] Clapham, Ch., Nicholason, J. (2009), *The Concise Oxford Dictionary of Mathematics*, New York: Oxford University Press Inc.

[9] Ellis I. (2009), *M.C. Escher and his magic*, Prague: Slovart CZ.

[10] http://www.slideshare.net/VinayakMahamuni/tessellation-tutorial-part1 [12/1/2015]

[11] http://www.mathpuzzle.com/tilepent.html [10/1/2015]

[12] Trch M. – Zapotilova, E. (2004), Problems, challenges and discussions – resources motivation in teaching mathematics, *Twenty-five chapters of mathematics educaton*, Charles University in Prague, 203-212.

## Authors

**Lucia Rumanová,** Department of Mathematics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Nitra, Slovakia, e-mail: lrumanova@ukf.sk

**Edita Smiešková,** Department of Mathematics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Nitra, Slovakia, e-mail: edita.smieskova@ukf.sk