DEVELOPMENT OF SPATIAL ABILITIES BY MEANS OF DIDACTIC COMPUTER GAMES

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Abstract. Students of engineering are expected to have a good spatial imagination, which is essential for their work. Most people have to deal with some kind of 3D environment as well. But how can they get familiar with an abstract 3D space? A spatial imagination is not easy to gain, students have a lot of troubles with it and the situation seems to be getting worse. It seems clear that we need more methods how to improve and develop the abilities. The aim of this paper is to show four didactic games and aids for teachers. Each of them offers a program, the background for solving problems and a set of tasks for children or students from 10 to 20 years. We offer teachers a didactic material and mention some experience with using this software at grammar school.

Keywords: Spatial imagination, didactic games, VRML.

1. Introduction

It has been frequently reported that the level of pupils' and students' spatial imagination is decreasing and more differentiated. It may be due to the change of the types of toys they manipulate with in their early childhood, and also due to the change of school curricula. It is essential to support and stimulate the development of these abilities at school more efficiently and intensively. The sooner we start the better. Opportunities for the improvement missed at the age of 10–12 years are difficult to substitute later.

Apart from essential manual manipulation, one way how to reach better understanding of 3D tasks (even seemingly without hard work) is using a computer, especially using computer (didactic) games. Students may enjoy the activity and teachers do not have to spend long hours preparing didactic materials.

The didactic games and aids for teachers that we offer are not closely focused on a particular topic of mathematic curriculum, they can be used whenever and require no preliminary pupils' mathematical knowledge. Moreover, the games can be effectively used by teachers who themselves do not have a good spatial imagination and thus tend to suppress or reduce geometric topics in their courses. Each of the didactic games offers a program, the background for solving problems and a set of tasks for children or students from 10 to 20 years. The games are freeware and require only web-browser with VRML plug-in (which is free, too).

2. Building Set

The first game – BUILDING SET – was originally designed to support the understanding of a coordinate system in 3D space. It was intended to be a game for young children, but it showed a lot of help for 18 years students, too. Mental orientation in space is not sometimes easy even for adults. The game requires pupils´ building of designed shapes in a text background. At the moment of designing pupils cannot see the scene they are creating, they have to imagine. They choose basic shapes and set their position and size in orthogonal

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coordinate system. Nevertheless, students can see the scene at any time just after clicking the button.

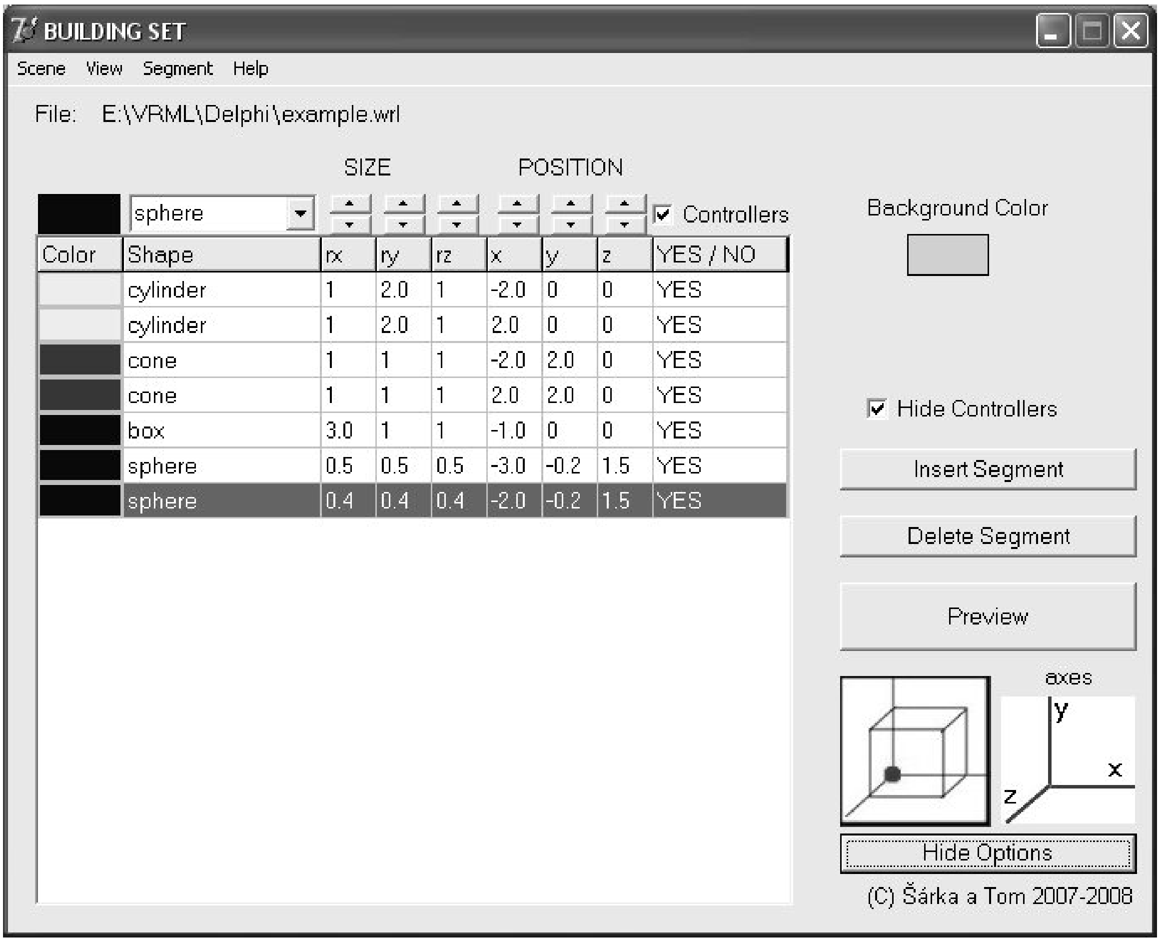

Fig. 1: The main window of the BUILDING SET editor

The game supports using a correct geometric terminology. Pupils can create their own imaginary scenes or build given shapes. Viewing and manipulation with resulting scene is realized – as well as in the other games – in a virtual space using VRML background. Game allows the selection of appropriate coordinate system.

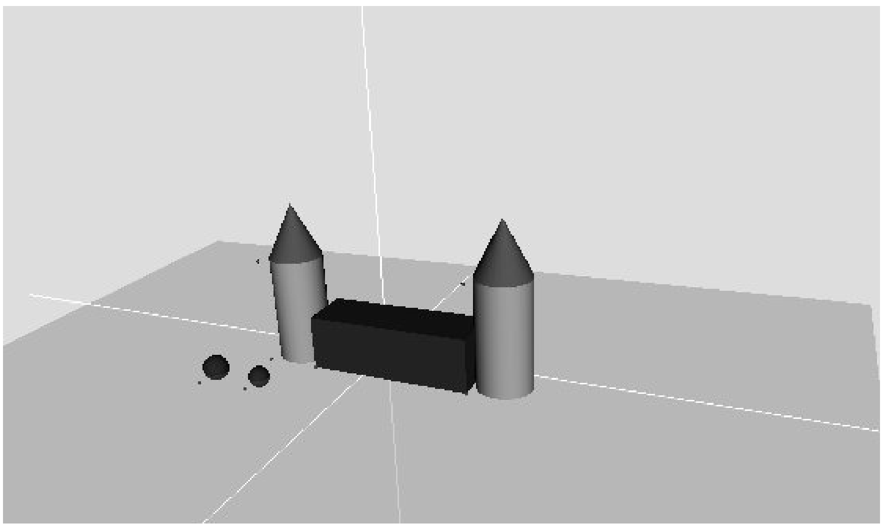

Fig. 2: The preview of the scene designed via editor according to Fig. 1

3. Game

The second game – “GAME” – seems similar, but it is more like a kind of a brain-teaser. The goal is to develop students′ shape and position imagination, to guess hidden parts, and to combine shapes. The solution is evaluated and students can revise their answers repeatedly until their correction. Arbitrary they can use the help – 3D view of the built-up scene. GAME can be used by young children and by 20-year-old students as well. We have created a set of approximately 30 tasks for this game. The demands of tasks increase from very simple ones to brain-teasers that train technical imagination. The game can be used at school training or as an interesting homework. Teacher can also receive a tool for testing students’ abilities. The record of student’s solution including the time elapsed is written into a text file.

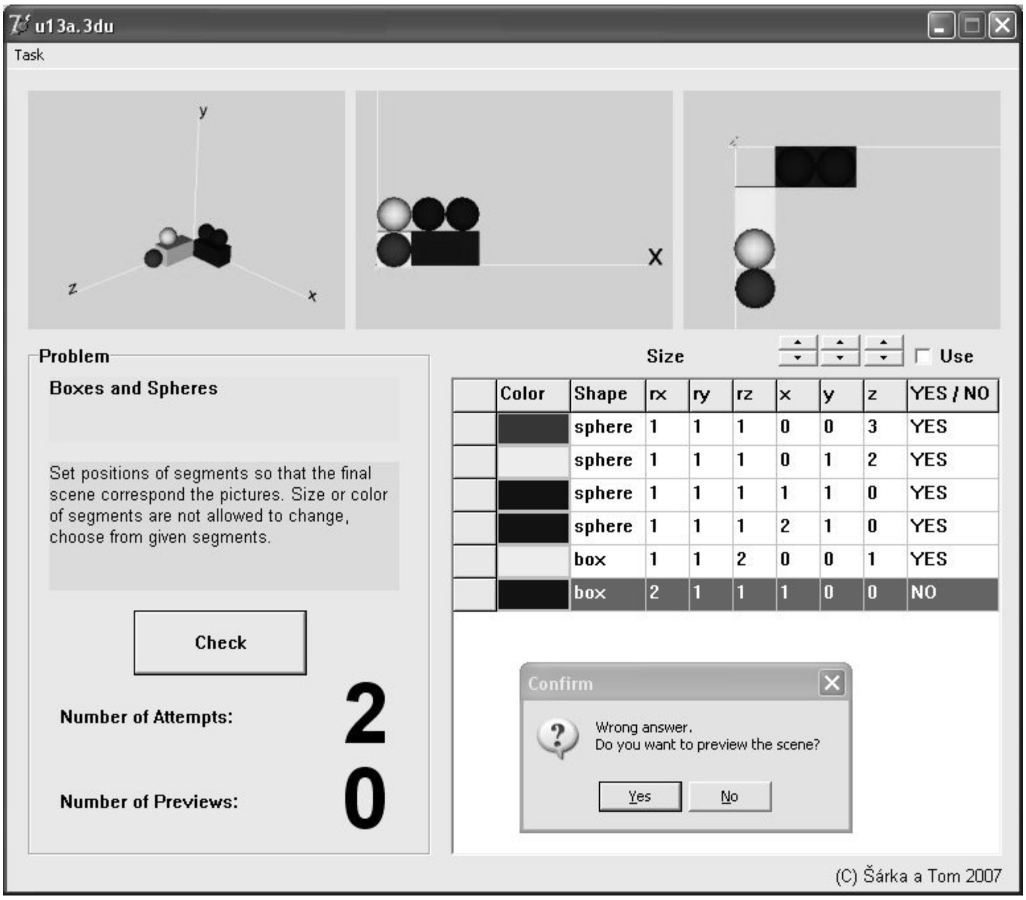

Fig. 3: Easy task – a game that requires the correct setting of positions of given segments only

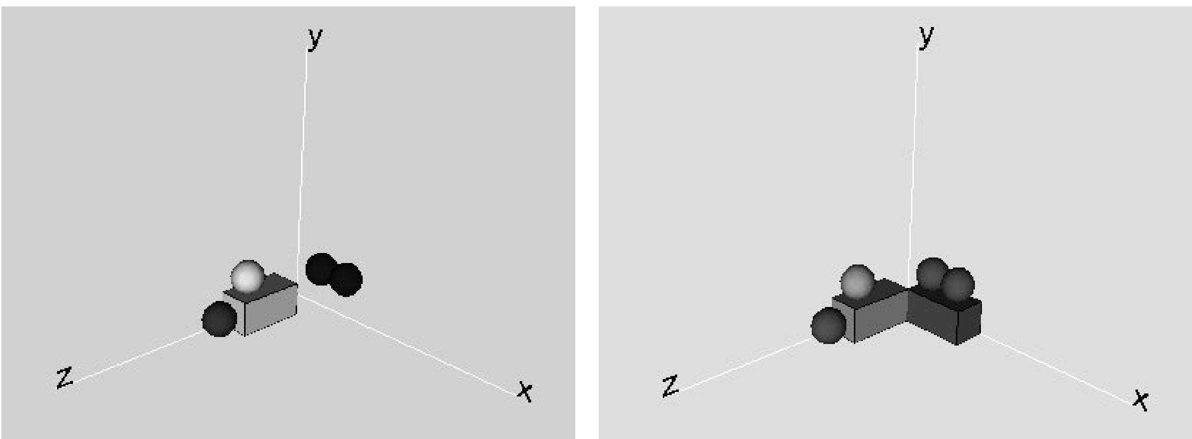

Fig. 4: An example of both wrong and correct answer of the task shown in Fig. 3

We have created a didactic background for using BUILDING SET and GAME in a lesson, see [1]. These games were used at grammar school lessons with 14 years students. While some students were struggling with the idea of coordinate system they had not met before, their swifter classmates were building houses and – later in the lesson – castles. Each of them followed their own pace but at the end of the lesson all of them were able to place (less or more quickly) the right shape of the right size to the right position. In fact, they were clearly aware of the true meaning of the conception of "ordered triple" (without naming it). The next lesson were students shown the "GAME". After having solved two easy tasks students were allowed to choose their following activity. While less advanced students immediately returned to the BUILDING SET and created coloured houses and castles, advanced students solved more and more complicated tasks in GAME, required further tasks (following almost the same pattern: "No! I cannot manage to do it!" …: "I have it!"), and never came back to the BUILDING SET.

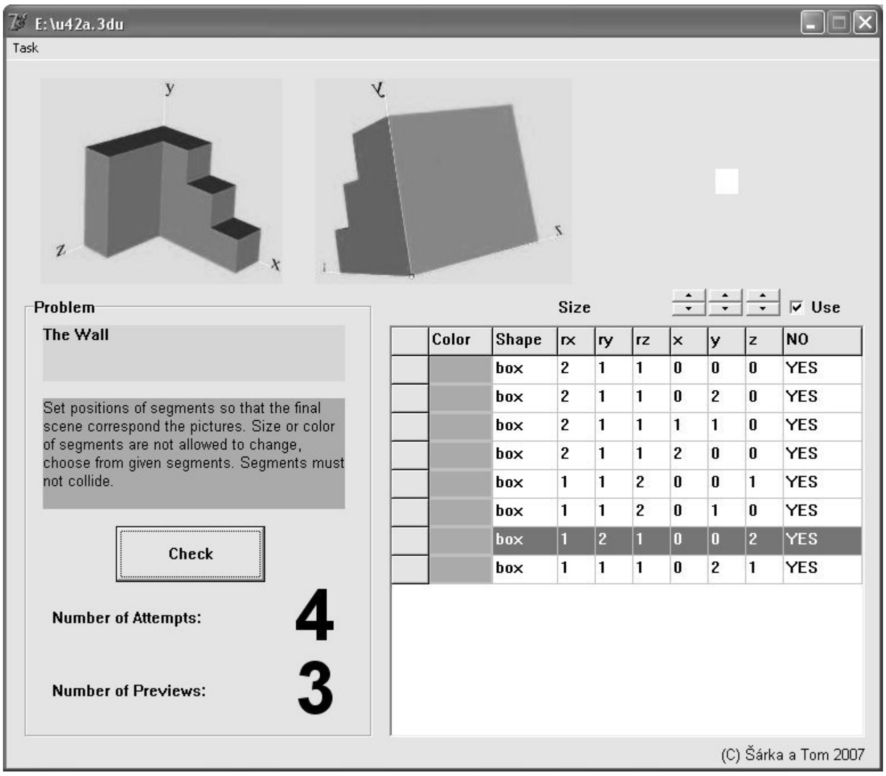

Fig. 5: One of the most complicated tasks. The edges of segments are not visible

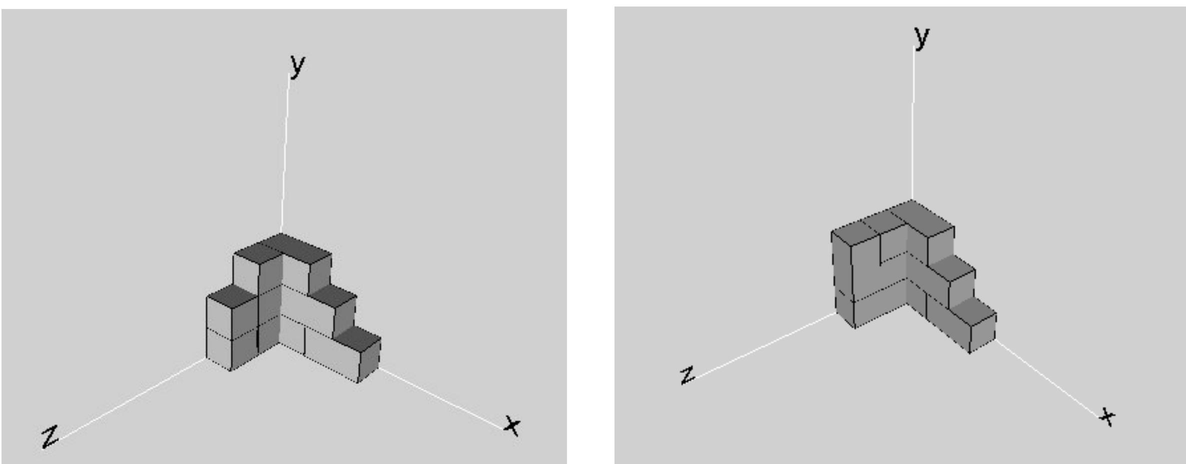

Fig. 6: Wrong and correct answer of given task. Shown edges can help players to check their mistakes

4. Cube

The third game – “UNFOLDING CUBE” – is a “live” version of well-known quiz: “solve how an unfolded net of a given cube looks like”. Students (or a teacher) can generate a cube (they can choose textures and a texture orientation of the sides of the cube), then examine (rotate) it in VRML 3D scene and then unfold it with hidden textures (for the demonstration of a correct solution it is also possible to see the textures during the process of unfolding). Finally, they draw the position and orientation of figures on blank sides of the net, while the textures on the original (folded) cube can be seen or hidden.

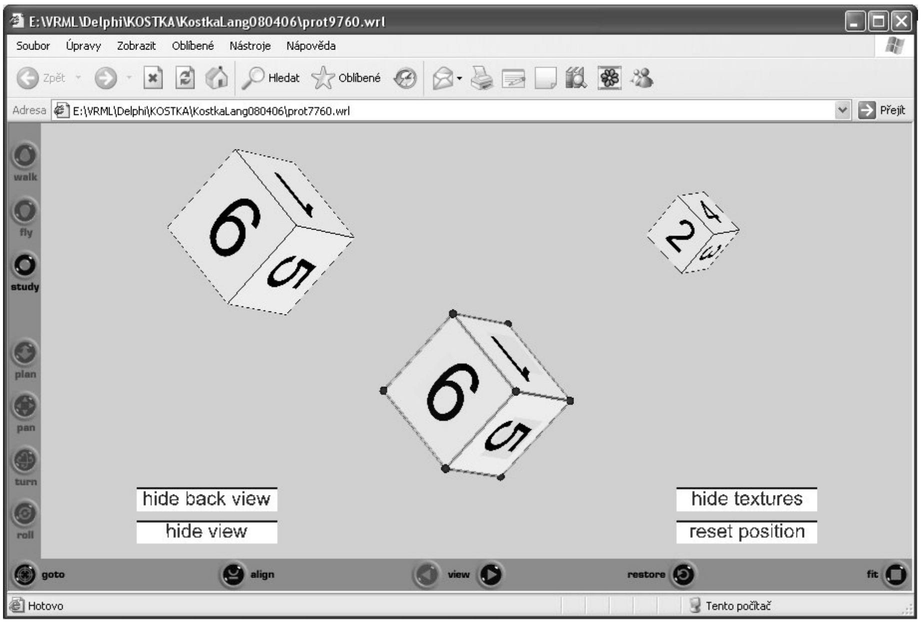

Fig. 7: The preview of given cube with two auxiliary views of the model

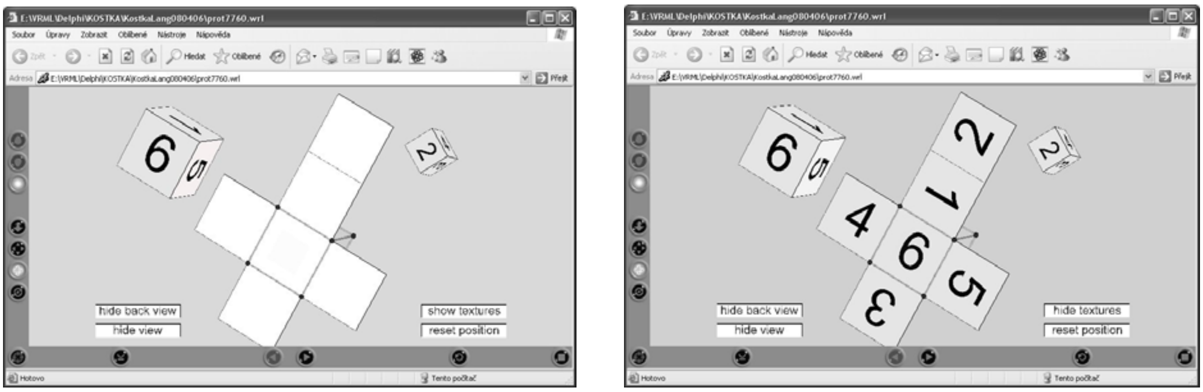

Fig. 8: The same scene with unfolded net of given cube with hidden and visible textures

The application also offers a tool that allows teachers to create easily a set of different printed tests and quizzes: filling up missing figures on sides of a net of a cube, searching wrongly placed figures, sorting nets etc. Moreover, a teacher can keep the model of the cube used in a particular quiz and demonstrate the situation to the students. Hand-making of such a test is terribly time consuming and it is always difficult to explain to the students the mistakes if you do not have a solid cube in real. The program can stand without it.

The process of solving the printed quizzes has demonstrated a great difference in the level of spatial imagination among students of the same age. While three of thirty 11-year old students correctly completed the test within ten minutes, the last three students were hardly able to find the key to the solution even with the help of a solid model.

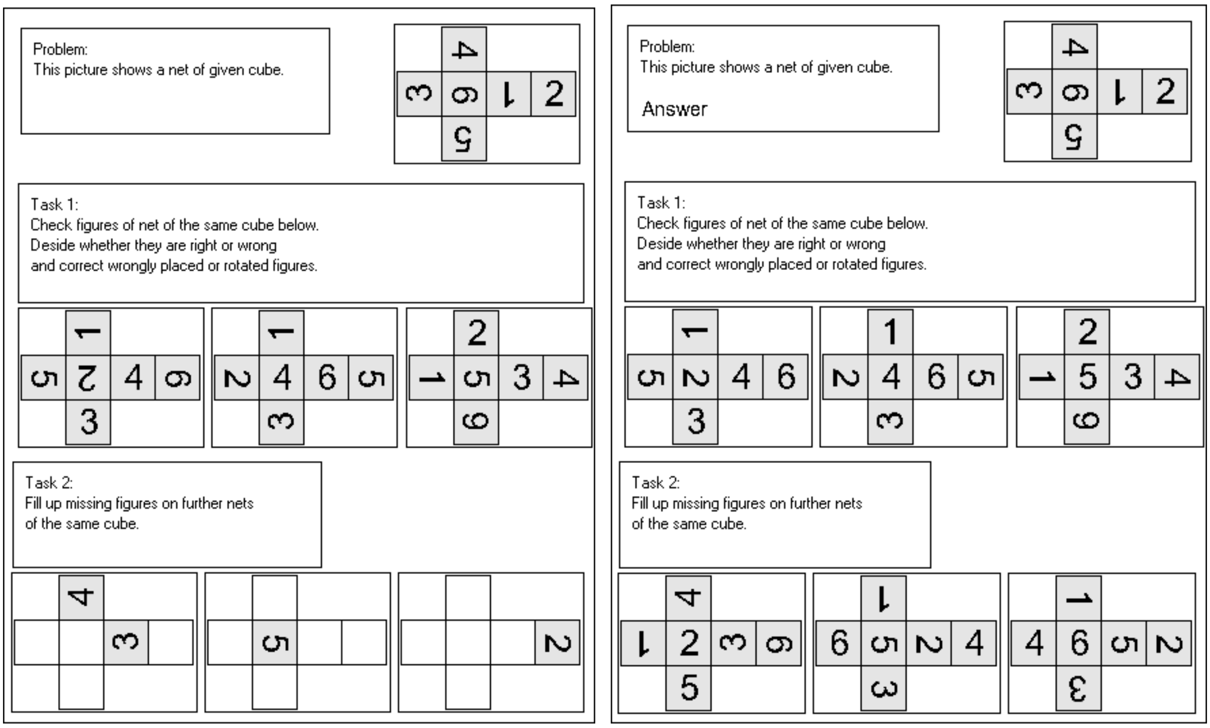

Fig. 9: An example of one possible printed test – the program helps to generate tasks and answer as well

5. 3D DOMINOES

The fourth game – "3D DOMINOES" is a dynamic, "strategic" game. It is more complicated version of a well-known desk game and it requires player's manipulation with cubes in 3D scene (via keyboard or manipulators) and wants player to connect the sides of cubes. By connecting sides equally "rated" (labelled), the player scores. The game in its basic version requires player ability to pre-arrange cubes in the scene, to remember the position and to combine the mutual position of cubes. The more sides the pasted cube fits to its neighbours, the higher the gained score is (1 for one side, 3 for two sides, 7 for three sides etc.). We have developed different versions of this game – a game for one or two players, a game where the time for one round is limited, a game with pre-arranged scenes and a game where the scenes are generated at random. In the version with pre-arranged scenes it is possible to choose the same scene for all students so that they could compete with one another. The game for two players allows to prevent a rival from annexing one's valuable positions and to plan the best tactics. 3D DOMINOES are based on the need of imagination of position in 3D space. The ability to remember the position and to combine mutual position is also beneficial.

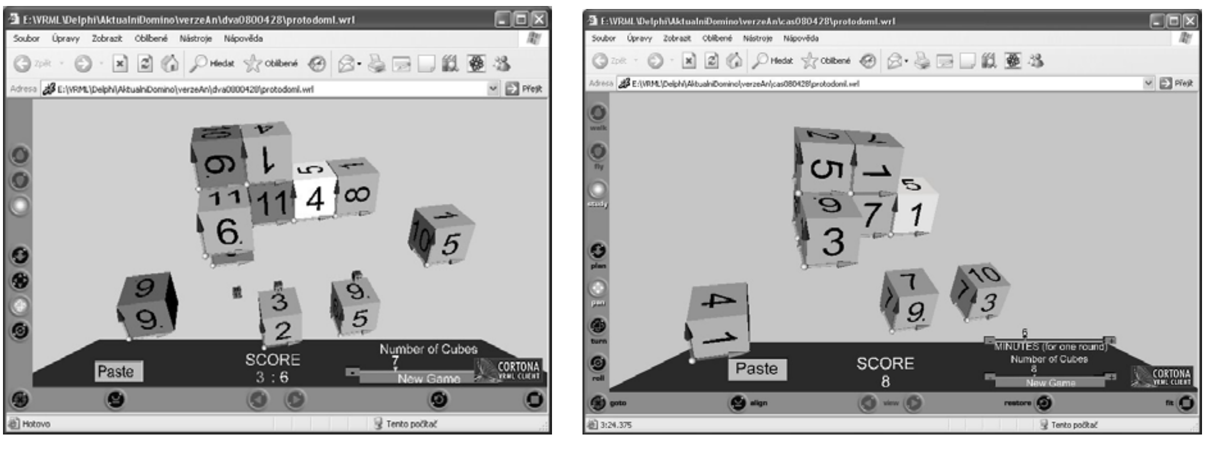

Fig. 10: Two examples of 3D DOMINOES – the game for two players, and the game with time limit

5. Conclusions

Using computers in classroom activities brings – besides its undeniable advantage – a lot of troubles and risks. Pupils and students tend to play and simply enjoy the game without gaining any knowledge. The ways how to avoid this include a precise and detailed teacher's lesson plan and individually formulated tasks. There is also another way: using the programs that essentially require such training abilities that when missed do not allow gaining the solution of the problem. The training of spatial abilities is a difficult task. But it is definitely worth trying and using computers and specialized didactic programs is a suitable way.

All programs can be downloaded from address: http://www.gbn.cz/sarka/hry/.

References

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ROZWÓJ WYOBRAŹNI PRZESTRZENNEJ ZA POMOCĄ DYDAKTYCZNYCH GIER KOMPUTEROWYCH

Studenci dyscyplin technicznych potrzebują do swojej pracy dobrą wyobraźnię przestrzenną. Mimo, że ludzie żyją i pracują w przestrzeni trójwymiarowej, to studenci mają kłopoty z wyobraźnią przestrzenną abstrakcyjnej przestrzeni trójwymiarowej i sytuacja wydaje się z roku na rok gorsza. Potrzebujemy zatem więcej metod dla rozwoju i przećwiczenia powyższych zdolności. Celem tego artykułu jest przedstawienie czterech gier dydaktycznych i pomocy naukowych dla nauczycieli. Każda z nich oferuje program – ramy rozwiązywania problemów – i zbiór ćwiczeń dla dzieci lub studentów w wieku od 10 do 20 lat. Oferujemy nauczycielom materiał dydaktyczny i przedstawiamy doświadczenia z używaniem opisanych programów w szkole średniej.