Platoground –game that connect teaching mathematics and physical education

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Abstract

Learning environments affect student achievement. Games create enjoyable environment. In this paper we will give an idea how an outside game can connect teaching of mathematics and physical education. We will describe Platoground-game that we have created in order to connect these two subjects and we will give some ideas for future research.

Kay words: teaching, math games, Plato solids,
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1. Introduction

Motivational and cognitive activity of pupils depends on the organization of the teaching process. The lack of these activities in the learning process makes pupils believe that mathematics is boring and pointless. As a consequence of this kind of teaching there is a lack of motivation, low level of subject competence, mathematical anxiety (that is a product of low self-esteem and fear of failure) [1,2]. According to [1] learning environment can affect the interest and motivation of pupils, the emergence of mathematical anxiety. Application of specific teaching methods can contribute to reducing mathematical anxiety [2]. One of consequences of the mathematical anxiety is low self-esteem, so it is necessary to help pupils to raise the level of confidence in themselves and in some cases that can be achieved by increasing physical activity [3]. Numerous studies provide different results about the impact of physical activity on academic attainment [4], but according to study [5] results indicate that there is a long-term positive impact of moderate-to-vigorous physical activity on academic attainment in adolescence, so school should be encouraged to promote physical activity. We came up with an idea that it would be good to connect mathematic and physical education because significant number of pupils spend their spare time mostly passively, their physical activity reduces over time, physical activity contributes to a better psycho-physical condition by reduction of stress, anxiety and so on [6,7].

The Van Hiele Theory

The Van Hiele's model of the development of geometric thought [8,9] has five levels (Table 1).

Level 0 (visualization)	the lowest level that starts with nonverbal thinking; figures are identified by physical appearance; it is based on recognition
Level 1 (analysis)	descriptive level, properties of figures are recognized
Level 2 (informal deduction)	there is logical order among properties (one leads to another); pupils can understand and formulate definition by using properties of figures, follow and give informal arguments
Level 3 (deduction)	pupils understand axiomatic system; proofs can be constructed by using axioms, postulates, definitions, theorems
Level 4 (rigor)	the highest level that is signed by abstraction; pupils can understand and work with different axiomatic systems, non-Euclidian geometries

Table 1. *Levels of geometric thought given by Van Hiele and their descriptions*

In the paper [10] Van Hiele's model of the development of geometric thought was applied in learning solid geometry and it was noticed that this level structure is not strictly linear and that at certain moments it comes to the interweaving levels.

2. Platoground

Knowing that learning environment can increase pupils' motivation, that increasing of self-esteem can reduce mathematical anxiety, that physical activities have a positive impact on self-esteem and that in the process of growing up pupils reduce their physical activities, we came up to an idea to connect mathematics and physical education. In our opinion learning mathematics through the game in new environment (outside, on playground) will have a positive impact on learning process (it is less strict, traditional and formal way of learning, so pupils are more relaxed). Since mental image is important for development of abstract thinking and it is based on experience [11], our game-lecture has to be based on gaining experience by using mathematical models.

In Serbia, pupils meet Plato solids in 3rd grade of secondary school (age approximately 17-18) and it is mostly informatively. We thought that it would be great if pupils could meet Plato solids even earlier, so we created a game called Platoground (this game was specially created for Family day, Visuality & Mathematics: Experimental education of mathematics through visual arts, sciences and playful activities that was held in Belgrade on 19th July 2014).

Platoground (see Figure 1) is educational and social game that can be played outside and inside (in large room like physical gym). Depending on the age of the players rules can be modified so everyone can play it. The number of players can be 2, 3 or 4. Each player has his/her own start point represented with circle on game's ground scheme (see Figure 1). Before the game starts each player gets five different colored Platonic solids (tetrahedron, hexahedron, octahedron, dodecahedron, icosahedron) for example first one gets Plato solids that are yellow, second one blue, ...) that have to be near start field-position. There is a marked dodecahedron (dodecahedron that has written numbers from 1 to 12 on it). Order of throwing marked dodecahedron during the game has to be established before playing it. It can be done by throwing

it, so that the order of received numbers determines who will be first, second, third and fourth. There are 16 fields on the ground that player can step during the game (equilateral triangle, square, regular pentagon, circle, four of each mentioned kind). The number of steps (number of crossed fields) depends on number received by throwing marked dodecahedron. The last stepped field (after one throwing) determines the way of moving on the ground in the next round and the number of winning points.

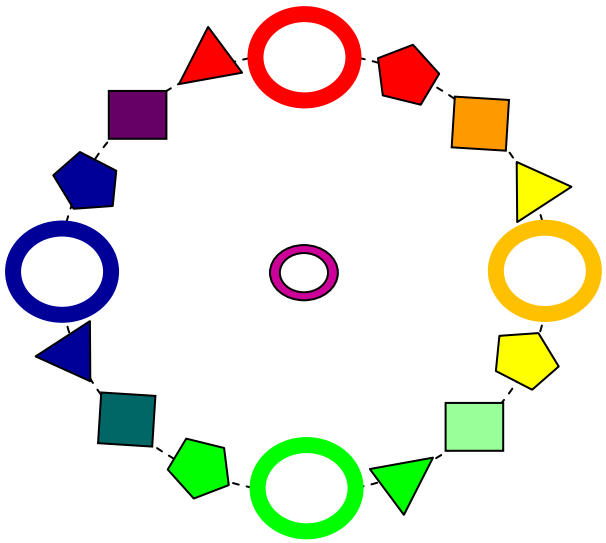

Figure 1: *Scheme of Platoground*

If a field is equilateral triangle then in the next round player will have to move by one-leg jumping, if it is square than he/she has to move by jumping (two legs jumping), if it is pentagon than by walking and if it is circle, player can choose the way of moving on the ground.

The number of winning points depends on solid that is connected to the field. Each field has one solid (pentagonal field has dodecahedron, square field has hexahedron) except triangle fields (each triangle field has three solids-tetrahedron, octahedron and icosahedron) and circle fields (each circle field has one player's collection of the Platonic solids). These solids are called field solids. Player wins point by throwing appropriate field solid into basket that is in the central part of the ground (marked as purple ring, see Figure 1). The number of field solid's sides is the number of winning points. In the case of the triangle and circle field (where the number of field solids is larger than one), the player has a right to choose a solid. If the field solid has already been thrown into the basket, then there are no winning points, unless the player has adequate field solid in his/hers collection of Plato solids (that can be used as a wildcard field solid). In the case of lack of adequate wildcard field solid or unsuccessful throwing field solid into the basket, there are no winning points for the player (in that round) and field solid has to be returned to corresponding field.

Circle field is a field of knowledge. In order to choose field solid from the collection, the player has to answer a question or solve a mathematical problem from a pulled-out card (problem is given by a teacher). In case of correct answer, player gets extra points (extra icosahedron) and a right to throw chosen field solid into the basket. In case of incorrect answer, he/she has to skip to the next round.

Square field is a field of sports. To win extra points (extra decahedron) the player has to fulfill the physical task given on the card that was pulled-out (the task is given by a teacher). If the task cannot be

fulfilled then the player has to skip next round. The game is over when there are no solids on the ground. The winner is the player that has the highest score (number of points).

Figure 2: *Platoground , Family Day during the Summer school, University Metropolitan, Belgrade, 2014.*

This game requires physical and mental activity. Its level of difficulty depends on players and it has to be determined by mathematics and physical education teachers. Certainly this game helps pupils to learn mathematic through the game, in more-relaxed situation (they learn which figure can be side of Plato solid, how many Plato solids there are, how many sides each Plato solids has etc.). Depending on pupils' age, teacher can give a task to pupils to make models of Plato solids, so that they will become familiar to solids' nets. Raising the level of knowledge and level of physical activity can be done thanks to fields of knowledge and fields of sport. Requests should be harmonized with the capabilities and abilities of the pupils and should be gradually increased.

3. Conclusion

If we want to make learning mathematics more interesting, we need to create new methods. Since learning mathematics is more inside activity, it would be great if it becomes an outside activity from time to time. We need to create and apply various learning methods in order to increase pupils learning motivation. That doesn't mean that we have to leave traditional methods, it means that we occasionally have to apply a new method so that we avoid monotony of our lessons. Platoground is one idea that provides us such new methods and helps connecting two subjects-mathematics and physical education.

Our future research will be directed towards assessment the effects of this learning method in primary and secondary school.

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