Optical ornaments in the teaching of mathematics

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Abstract

For many students, mathematics is difficult, but our task as their teachersis to make students understand that mathematics means more than just numbers and that it is omnipresent: in nature, in art, in music, etc. Teachers are supposed to achieve that goal by using old and new methods of teaching.There is a series of advantages of group work in the teaching of mathematics, despite the plan being educational or moral.Taking into account all aspects, it dawned upon me that I might use optical ornaments in combination of mathematics and art lessons. The main aim was to lead students to learn what group work is and to use that knowledge in the process of teaching mathematics.Another aim was to make students realize that doing math is like doing a Jigsaw puzzle – by using simple elements, you can make complex structures, while doing some mathematics exercise means combining some concrete basic knowledge for a particular field.

Key words:optical ornaments, mathematics, art, group work, jewelry

MSC: 97U30, 97D40

1. Introduction

According to syllabus, the aim of teaching mathematics at grammar schools is adopting of mathematical knowledge by students. It also should contribute to all-round development of students' personalities. During mathematics lessons, students should develop awareness on universality and the application of mathematical knowledge and way of thinking.

Aims and tasks of art as a subject are interwoven with aims and tasks of mathematics. Many competencies of students necessary for mathematics lessons should be developed at art lessons.In accordance with that, an essential aim of art is to develop awareness on close association between art and science, nature and society.Students should develop visual observation, creative thinking, curiosity, creativity, innovation, self-confidence, and also they should be trained to work individually and in teams.

One of important demands in the process of teaching mathematics is to make students learn it mainly during the classes. This can be accomplished only if all the students participate actively in the teaching process. Group work activities are one way to do that. Some downsides of frontal work can be eliminated using group work and students would be able to take in more knowledge and to increase self-esteem, motivation and willingness to work.

When students experience even the smallest change in the teaching process, they become more interested. For that reason, this paperwork will show how group work can be made better at combination lessons of mathematics and art. Students will familiarize themselves with group work and mathematics in a natural way while developing self-esteem and creativity.

An important part of teaching mathematics is visualization with its aim to make understanding of mathematics much easier.The aim is to show some mathematical structures and their characteristics in drawings and animations. Art can be enriched in that way and vice versa.

For this purpose I used Optical ornaments at lessons I organized along with my colleague, Art teacher. Students familiarized themselves with modularity in art and types of modularity lying on the border between mathematics and art (spatial mosaic, interwoven mosaic and optical mosaic).
The main aim of my work is to describe one way which might help students approach group work differently at mathematics lessons.

Inspired by the beauty of optical ornaments, I have made a jewelry collection about which I will write in this paperwork as well.

2. Group work

Students are different when it comes to their mathematical abilities, foreknowledge and psychophysical characteristics which should be coordinated with syllabus in order to make the teaching more successful. In that way, students will learn mathematics mainly during lessons.
Aside from frontal work, pair work and group work should be introduced so as to achieve better results in education.

Group work means that students of one class are divided into more groups. During the lesson, each group performs the tasks supervised by the teacher. Students can be split into groups according to different criteria. Students should increase their self-esteem during group work, develop individual responsibilities, learn how to communicate better with others, and get used to helping each other. Topics exploited during lessons are interested enough to make students continue work at home. They find additional literature, and watch TV programs concerned with their topic. Group work helps them to learn and study. They come to realize that group cannot "learn" instead of a member of the group but can help him/her learns easier and understand something better.

However, despite all the advantages of group work, best results can be achieved if all forms of work are functionally combined together. Modern teaching process should be dynamic and diverse, and it also should include individualization and innovation.

It is well known how much time it takes to organize these types of lessons. When students start secondary school education, they are already grown-up and they have some foreknowledge as well as some habits which are not so good. When I talk about this, I mainly refer to their understanding of group work. That is the reason we cannot be exactly sure what students think of group work and whether they believe they should all take part in the activities within the group or only some of them might do the given task. In order to make these group activities successful in class, we should make students realize what group work is and to make them get used to this form of work during mathematics lessons. I have decided that by combining mathematics and art, I phase in group work in the teaching process and make sure that that form of work goes from strength to strength after every group assignment.

3. Modularity in art

As the modularity we considered the use of several basic elements (modules) for constructing a large collection of different (modular) structures. What is modularity principle in science and art?
Accordingly to [1], "in science, the modularity principle is represented by search for basic elements (e.g. elementary particles, prototiles for different geometric structures, etc). In art, different modules (e.g. bricks in architecture or in ornamental brickwork, etc) occur as the basis for modular structures.In various fields of (discrete) mathematics, the important problem is the recognition of some set of basic elements, construction rules and an (exhaustive) derivation of different generated structures...In a general sense, the modularity principle is a manifestation of the universal principle of economy in nature: the possibility for diversity and variability of structures, resulting from some (finite and very restricted) set of basic elements by their recombination. In all such cases, the most important step is the first choice (recognition or discovery) of basic elements. This could be shown by examples from

ornamental art, where some elements originating from Paleolithic or Neolithic art are present till now..."

In many cases, the derivation of discrete modular structures is based on symmetry. Using the theory of symmetry and its generalizations (simple and multiple antisymmetry, coloured symmetry, etc) for certain structures it is possible to define exhaustive derivation algorithms, and even to obtain some combinatorial formula for their enumeration.

As the example of modular structures lying on the border between the art and mathematics could be considered:

- The set of modular elements for derivation of possible and impossible objects "SpaceTiles";
- Different knot projections occurring in knot designs (Islamic, Celtic, etc) derived from the regular and uniform plane tessellations by using few basic elements "KnotTiles";
- Antisymmetry ornaments and their derivation from few prototiles – "OpTiles";

If we consider the Paleolithic key-patterns, Celtic ornaments and op-art works, we can see their joint basis: basic (anti)symmetric prototiles obtained by a division of a rectangle with their diagonal lines into two antisymmetric (complementary) prototiles, where one of them or both are used. This can also explain somewhat hesitating visual impression that such patterns produce: the constant effect of flickering, when the eye recognizes black and white pattern and oscillates between them. From "black-white" prototiles we can obtain the corresponding black-white patterns. The series of such tilings derived from the four prototiles is represented by "OpTiles". Most of antisymmetric ornaments could be derived by recombination of few basic "OpTiles".

If we try to explain what we see as one object, we come to the conclusion that we actually have a variety of objects to choose from. From this infinity, our perception most often opt for one "natural" (or the simplest possible) interpretation.

4. Class work

The aim of combination mathematics and art lessons is to make students realize that mathematics is all around us and make them create positive attitude towards mathematics in general.
Group work is essential for this purpose. By using optical ornaments in class, students will realize a huge application of mathematics in art which was present in distant past as well.

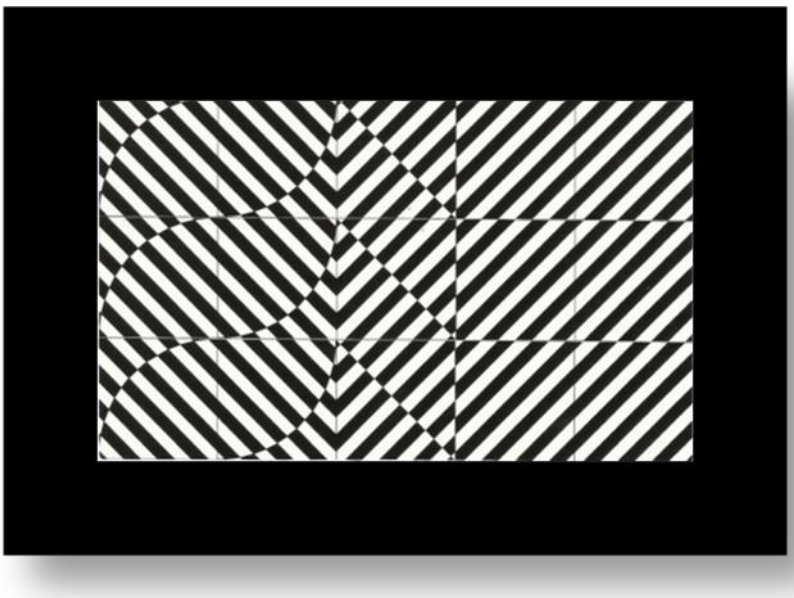

Figure 1. Paper with basic elements

It is advisable that mathematics and art teachers be present so that students can get used to their presence. During these lessons, students familiarise themselves with the notion and types of modularity in art, so15-20 minutes of the lesson should be dedicated to showing students the link between mathematics and art, they should be taught about modularity in art and visual perception as well.
Slide presentation is used during these lessons. Lecture is short and simple in order to motive students for work afterwards. After lecture about modularity, students are spited into groups of 4 or 5 members (at first students might split into groups as they like and afterwards according to different criteria). Students should be explained the method of work.

Each group of students has sheets of paper with basic elements drawn(Figure 1), scissors, glue and white piece of paper. Students cut out basic elements and then use them to make complex structures. In the end, they stick those structures onto a white piece of paper. Teachers supervise the work and give students some additional instructions and explanations, at the same time they encourage team work.
Due to the beauty of optical ornaments and the impression they make on every individual, students are sure to participate in the work, without hesitation. At first, students choose to do one creative assignment within the group since they feel more comfortable that way, but later on they come to realize that making more complex structures is not so hard and they plunge into making their own ornaments. At this moment, their self-esteem is boosted and they become more creative. Even those students who are not so good at mathematics realize they could do the task on their own.

Mathematics is not a bogey anymore. It is imperative that these lessons should be organized during double period so there is enough time for all activities.At the end of the class, members of each group showtheir work, compare notes and talk about visual perception and the particular feelings these ornaments inspire in them. They also talk about where mathematics is present in all those works (symmetry, asymmetry, rotation, etc) and about application of these optical ornaments in real life (clothes, jewelry, etc). After the lesson, students take pride in their works and boast about them.
Some of students' works are shown in the following picture:

Figure 2. Some of students' works

5. Conclusion

During this type of lesson students were highly motivated for work and there was a positive, creative, and working atmosphere. After the lesson, students stop considering mathematics purely as formulas. When they think of it, they see the beauty of its application and that special feeling optical ornaments inspired in them.

Solving mathematical exercise is now the same as doing jigsaw puzzle - by using simple elements, you can make more complex structures - in mathematics students apply basic knowledge to solve more complex exercises.Students are actively engaged in the teaching process and successfully achieve set goals if various methods and means of work are combined correctly and creatively. In the mathematics teaching process it is essential to develop the following qualities: determination, motivation, self-reliance, perseverance, and resourcefulness.

After these lessons, students are more concentrated and are ready to come to grips with different exercises on their own and not wait for others to help them. Better working atmosphere is created and better results are achieved in tests.

The pride of all my work with optical ornaments is the jewelry collection inspired by the beauty of optical ornaments. Jewelry like this is always popular, everywhere and with everybody, irrespective of what the fashion sets at that moment. It cleanses our minds from every environmental impact. When it comes to my students, they take great pride on the fact that their ornaments, besides my own, can be seen on these pieces of jewelry.

Figure 3: Jewellery inspired by optical ornaments

6. Literature

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