Fractal structures in architectural high school

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Abstract

Within this work it will be presented how the teaching of geometry can be more interesting and more accessible to students in architectural high school by using various modern media. The authors have tried a different approach to motivate students to identify geometric shapes in the world around us and to describe their properties using mathematical language. It also shows the correlation between maths and art. The motive for this approach to teaching math is raising the level of students' motivation as well as the aim to bring them closer to mathematical concepts through visualization.

Keywords*: teaching mathematics, subject of arts, computer applcation.

MSC: 97U30, 97D40, 97D80

1.   Introduction

A large number of students in our school are interested in studying architecture. The curriculum for mathematics in architectural high school and the Faculty of Architecture are quite different. We wanted to introduce the students to certain concepts which are studied at the faculty on an intuitive level. We were highly motivated because we believe that introducing students to some of the mathematical concepts at an intuitive level will be of great help in mastering tasks easier in the future.

We decided to use the fractal topic because it is a very interesting mathematical concept that is an integral part of the course of Mathematics at the Faculty of Architecture and because various fractal structures are present everywhere around us. They can be seen in the architectural buildings, art, nature, genealogies and our body.

We tried to present this topic in each class.

During our preparation for the work in the classroom, we became familiar with the works of other colleagues on this topic. We tried to adjust this complex mathematical concept to high school students,

but also to monitor the content done at the university. Experience of colleagues that we found on the Internet was of great help.

Here we give a brief overview of activities by grade:

2.   The first grade

On Maths lesson

The moment when we introduce the term fractal is after teaching unit on Similarity. We thought this was a good time to talk to students about self-repeating of shapes, figures and bodies. Teaching units we previously dealt with in detail were Isometric transformation and Homothety. Also, at the end of these topics, the students had a knowledge test.

Slide presentations were of great help. A lot of our presentations were based on the use of these sites. We used a rich knowledge Data base of Creative school (http://www.kreativnaskola.rs). We presented the visual beauties of this field of mathematics by displaying images and films. It was very convenient to use a ready material for demonstrating some of the concepts and figures, as well as characteristics, exploring the definitions, theorems.

The students collaborated more with each other, but they were also more active in the student-teacher communication. They willingly participated in analyzing the presented images, films, self-repeating details.

All displayed presentations, photos, movies, students are able to find on our website, which was created just for this theme and re-examine them individually. Web page address is http://www.alas.matf.bg.ac.rs/~mm97045/homotetija/.

Homework

We insisted on visualization and identification of fractal shapes in the world around us. Furthermore, self-repeating of shapes was one of the themes on which we put the emphasis. The students had to make fractal out of paper for their homework. Some of them did this on maths lessons and some independently at home. In addition to paper visualization, the children were given the task to identify in their surroundings a fragment of fractal geometry and to photograph it. They had to forward the pictures to the teachers by e-mail. Apart from this type of homework, the students also had a regular homework to solve the problems from the exercise book. Our opinion is that only a combination of traditional and contemporary teaching approach can provide with the best results.

Fractal paper design book

During our work on the fractals crated out of paper, a new idea emerged that we want to elaborate, and it was making a paper collection of fractals which would be nicely painted and ornamented and which would be used as a mean of introducing new students to this term. We called this picture book A FRACTAL PAPER DESIGN BOOK (FRAKTALNICA). The students were highly motivated to participate in the making of paper collection of fractals. The most suitable paper models were put into a collection.

Figure 1: *A fractal paper design book*

A fractal paper design book can be seen on the blog <u>milenajeretin.wordpress.com</u>.

Assessing knowledge

At the end of this teaching process, the students were tested. This part of the teaching process was implemented by maths teachers Milena Jeretin i Milena Maric with students in classes A14 and A15.

3.   The second grade

Considering the fact that the students were very interested, we wanted to expand their knowledge and apply it. Although the topic Similarity is not in the curriculum for mathematics in the second grade, we decided, within one maths lesson, to revise gained knowledge about the concept of Fractal, amend it and prepare the students for its application in the subject of Art, which is intensively studied in the second grade by our students.

On Maths lesson

Within the maths lesson we revised the concept of self–similarity and fractals and complemented their gained knowledge with where we can observe fractal structures in our body and the world around us using presentation and films. During that lesson the students drew several simple examples of fractals: Koch curve, Koch snowflake, Sierpinski triangle, Pythagoras tree. Due to the fact that our genealogy (genealogical tree) has a fractal structure, we connected the fractals with genealogical tree. Students were given for homework to do their genealogy in electronic form, on paper or in the form of 3D models. In addition, they had the opportunity to re-watch all the content from maths class on the blog <u>milenajeretin.wordpress.com</u> and for their homework they had to individually complete the test of fractals at the same blog. They were divided into groups with a final project for homework, at the agreed time, to do a poster, film or presentation on fractals.
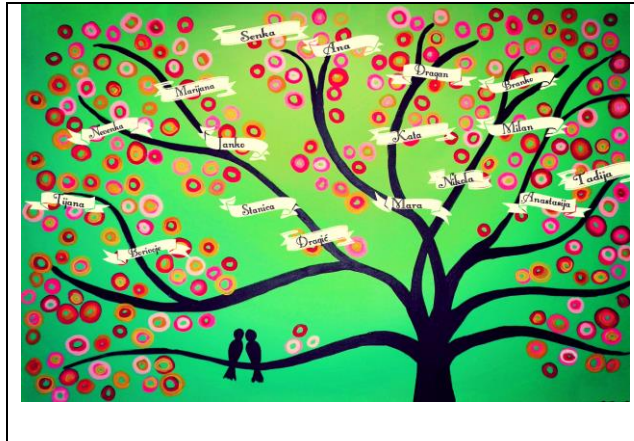
Figure 2: *Genealogical tree*

On Art lesson

On Art lesson, the students linked the fractals to the rhythm and gradation and made drawings which illustrated the application. Using the examples from the world around us, the students were acquainted with the types of rhythm and trained for their own observation. Using the examples from the history of art, they recognized the significance and understood the application of mathematics in the works of art, applying the knowledge gained in the maths lesson. They were introduced to the symbolism of numbers and the way of making stained glass and ornaments in medieval art, after which they started making their own stained glass. At the end of the lesson they received the instructions for the homework assignment in which they used gained knowledge of optical art to create rhythm using gradation in composition. On www.pinterest.com the students put the photos of their work and their analysis. The aim for the students was to enrich personal vocabulary with artistic terms as well as to adapt to using different techniques, tools, media and methods in problem solving.

In order to facilitate the monitoring for students and encourage their interest, we established a link on the Internet on the blog milenajeretin.wordpress.com, site http://manojlovicjasmina.wix.com/ats-crtanje and www.pinterest.com.

Final group work which the students had to do for their homework was presented on the following lesson which was mutual for Mathematics and Art, after which we organized an exhibition.
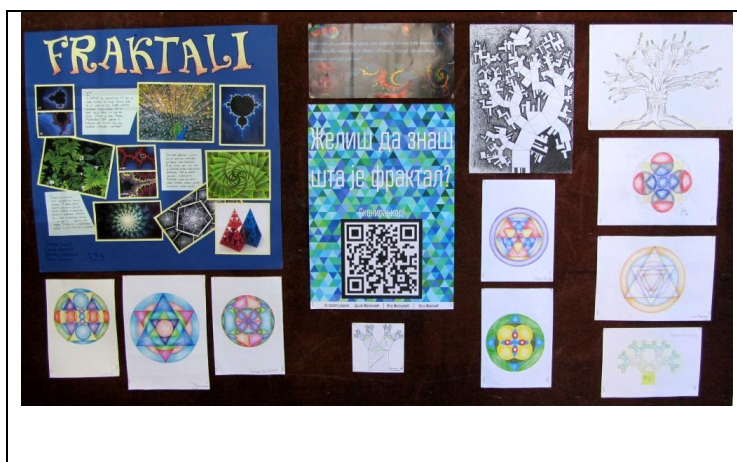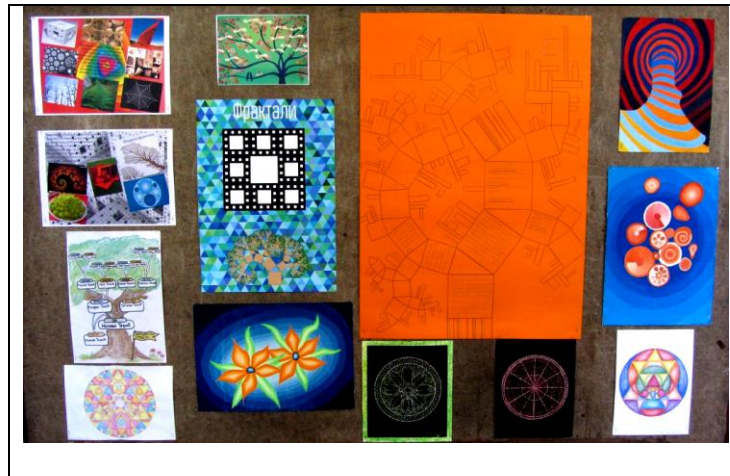

Figure 3: *Exhibition*

Figure 4: *Exhibition*

This part of teaching process was implemented by Milena Jeretin, maths teacher and Jasmina Manojlović, art teacher with the students in classes A24 and A25.

Our activities in the next two lessons are theoretically devised and are yet to be implemented. The goal is to shape the four-year story that one generation has learned, told and made about the topic of fractals. We also want the future generations to improve this idea with us.(see [19] Fraktali i ritam)

4. The third grade

At the beginning of the school year we visited the Ethnographic Museum and realized the workshop "The search for the fractal structures in the cultural heritage" in the cooperation with Tijana Čolak-Antić. Each group of students should have looked for designs on the exposed clothes in the Museum. They have become familiar with the cultural heritage by Tijana Čolak-Antić representative of the Museum. Students have observed a fractal structure in the exposed objects.
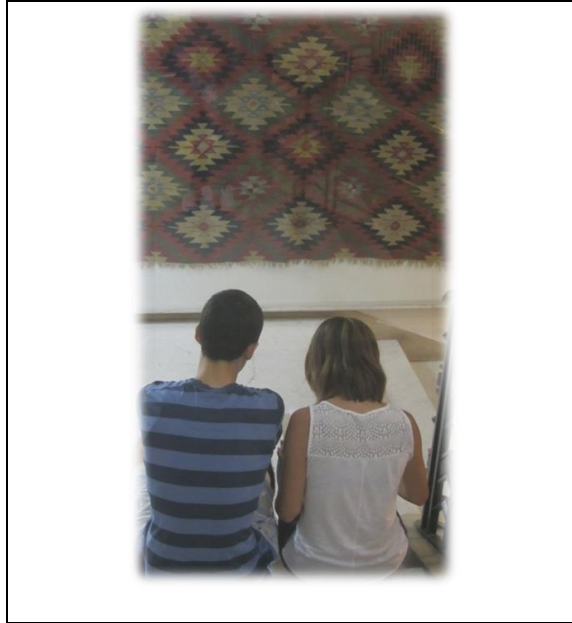
Figure 5: *Pirot rug*

They drew a fractal design on the paper or used applets on the site
http://csdt.rpi.edu/african/African_Fractals.

At the end of the school year, when the students should learn about sequences, we plan to organize a maths lesson where they will see a presentation of Geometrical sequence and row, by Kata Jovanović, Gorica Acketa, Ratka Čorda from the site http://www.kreativnaskola.rs and to organize a jewelry workshop and pendants on the topic of fractals. This part of the teaching process will be implemented by Milena Jeretin, maths teacher and Jasmina Manojlović, art teacher with the students.

5. The fourth grade

In the fourth grade one maths lesson is planned to renew and amend with new content the topic of Fractals - in the subject *Composing shapes* to make 3d models of fractal structure, which has already been done in the previous year in the experimental group. Students were acquainted with the application of fractal structures in architecture throughout history and creation of buildings of exceptional beauty. They are encouraged through discussion to find and analyze by themselves the application of rhythm by gradation as well as to establish correlation with mathematics. After that, an artistic problem was established and the students approached the realization of special model using gained knowledge and materials they chose by themselves. On www.pinterest.com they put the photos of their works and performed analysis using gained knowledge.

The aim of these lessons was for students to understand and adopt the methods that exist in the field of synthesis in art, mathematics and architecture on the level of more complex artistic research, within the spatial model.

This was implemented in the experimental group of students by Milena Jeretin, mathematics teacher and Jasmina Manojlović, composing shapes teacher.

6. Conclusion

Mathematics is a subject that most students consider to be extremely difficult. The nice thing about mathematics is that it is a science that can be found in almost all spheres. Tendency to bring complex mathematical concepts closer to the student through the connection with other subjects and visualization should become the trend and goal for the teachers of mathematics.

Our previous experience shows that this approach is correlated with students' motivation to work.

That's why our new challenge is to connect the concept of fractals with some other professional teaching subjects and improve Fractal paper design book with new art techniques, as well as the formulation of didactic content on Fractals through all four years.

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