Good practices
PROG_208_CD_EN

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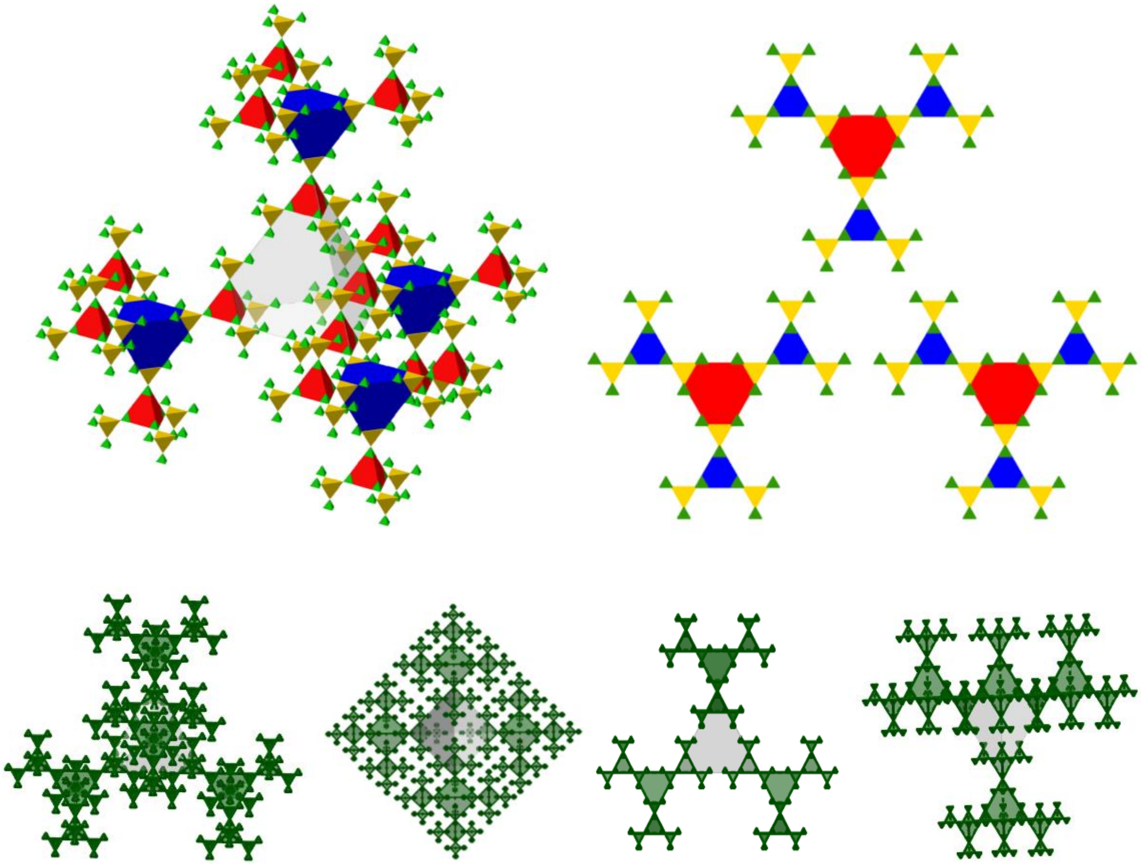
Description of the problem / exercise: **Poly-Universe and GeoGebra — Poly-Universe and Fractals**

In GeoGebra, it is perhaps the drawing and coloring of fractals where we can best express our creative tendencies. These fractals can be colored - corresponding to the Poly-Universe or different from it, monochrome, with different shades of parts, made in plane from triangles, squares, or based on a tetrahedron or cube in space. The projections of spatial fractals can also be very interesting.
In the process of drawing and studying fractals, we can calculate the circumference and area of the overall shape at each step. We can study what the limit of the perimeter or area will be if the number of steps goes to infinity. Can an infinitely long broken line be placed in a finite area? We can explore the concept of dimensions, why are fractals fractional dimensions?



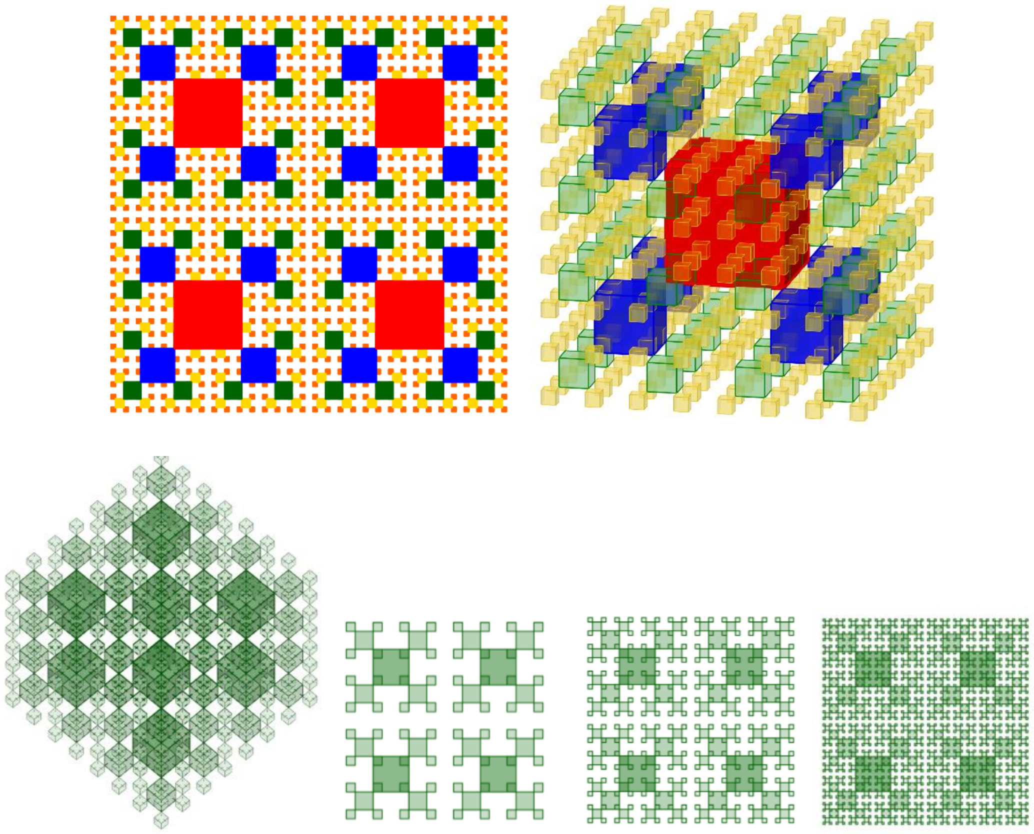


Figure 1: Various triangle, square, tetrahedron, cube-based fractals and their projections

The creation of fractals in the GeoGebra book is very similar. First, you draw the initial shape, which can be a planar polygon (triangle or square in the book) or a spatial polyhedron (tetrahedron or cube in the book). Then we arrange the vertices of the initial shape into a list. In the next step, a sequence of the initial shape is created with the elements of the vertex list as the centers of similarity, of course, the ratio of similarity must be given. This gives us another list. Then we repeat this step as often as we see fit, only always replacing the old list with the new one. The steps copied from the GeoGebra algebra window for a triangle are shown in Figure 2.

```
A = Intersect(xAxis, yAxis)
B = (8, 0)
poligon1 = Polygon(A, B, 3)
f = Segment(A, B, poligon1)
l1 = {A, B, C}
l2 = Sequence(Enlarge(poligon1, -(1 / 2), Element(l1, k)), k, 1, 3)
l3 = Sequence(Enlarge(l2, -(1 / 2), Element(l1, k)), k, 1, 3)
l4 = Sequence(Enlarge(l3, -(1 / 2), Element(l1, k)), k, 1, 3)
l5 = Sequence(Enlarge(l4, -(1 / 2), Element(l1, k)), k, 1, 3)
a = 4
0 4
Input...
```

Figure 2

https://www.geogebra.org/classic/rj28vzjv

https://www.geogebra.org/classic/udjqxevk

https://www.geogebra.org/classic/sp928yza

https://www.geogebra.org/classic/zptnhkhm

https://www.geogebra.org/classic/dprqprjx

https://www.geogebra.org/classic/xke6qdkk

https://www.geogebra.org/classic/bmrauujp

- *Why this exercise is good:* There are lots of different tasks for different age groups to choose from. We can talk about where we find fractals in nature, in art (in the art of János Szász Saxon). We can go from simple problems of calculating perimeters and areas to the theory of infinite series.
- *Which level is recommended:* secondary school, teacher training (mathematics, IT)
- *School subject(s):* Mathematics, IT, arts