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“Kockalica” (cubes) – didactic and manipulative teaching resource in methodology of developing mathematical concepts in kindergarten

1. A child and maths

Galileo Galilei (*Galileo Galilei*, 1564–1642) said that “nature speaks to us via mathematical language”. Our mathematical knowledge is the reflection of **quantitative relations** (in family, home, street, nature, kindergarten, playground...); **spatial characteristics** (shapes, dimensions), **objects and phenomena** of the real world. Mathematical concepts derive



from the factual reality-our close environment and they are not a result of thinking process! They are conditioned by our practical needs and problems such as counting money, measuring mass of materials, time...therefore, our direct surroundings represent inexhaustible source for the development of the initial mathematical concepts of children.

The process of development of initial mathematical concepts at children population is conditioned by children’s nature, their knowledge and the type of mathematical content. Kindergarten children is curious in its nature and the process of acquiring knowledge happens directly throughout meeting the objects in the surroundings via the need “to ask” (the questions are motivated by expanding the experience) and the need to be active – to play, participate and to manipulate objects. Thus, children research the world around themselves and get to know the characteristics of phenomena and objects, their various possibilities.

Children learn and perceive the world via method of trial and error and by searching for new ways of learning. That is why we can certainly claim that “a child is a great explorer of near surroundings that is inexhaustible source of knowledge!”.

The first contact of a new born with its surroundings is made via senses (touch, taste, smell, and later sight and hearing). Firstly perceived information

are general anent undifferentiated. Thus a child does not make the difference between itself and the world around (it equals subjective and objective, alive and non-alive, natural and artificial...). These experiences are not continuous they are intermittent and every child forgets it in time. A child still manages non-developed system of receiving and processing the information. Gradually, under the influence of learning activity, by the influence of social environment more complex symbolic systems take place (language, system of mathematical concepts, norms...), and therefore the innate dispositions develop.

Motoric activity of children contributes the development of perception (movements, touching, manipulating objects...). This activity does not have the mere function of satisfying the needs but it also have the function of organizing various types of perception. Because of this, psychology claims, "that knowledge origins are in sensory motoric!" By doing sensory and motoric activities through a game the interiorization appears (in the internal plan outer reality and practical activity transfers) which produce conditions for the mental capabilities development.

According to Bruner [1972]: "Actions precede higher forms of cognitive stages" (perceptive-manipulative activity). Since mathematical concepts represent higher forms of knowledge the introductory phase mathematical concepts development must have the character of practical and perceptive activity of a child at its direct surroundings.

That is why we may claim that mathematical content are the result of children's:

- **Practical** (perceptive-motoric) activity in surroundings,
- **Process of interiorization,**
- **Logical thinking** (abstraction and generalization) and
- **Mathematical content are highly abstract** (do not relate real phenomena and things).

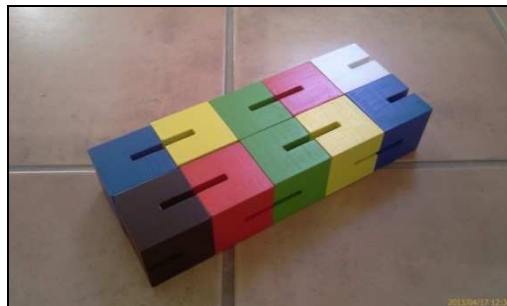
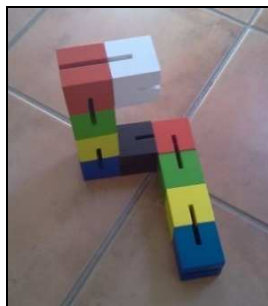
The process of building the mathematical concepts has two stages:

1. **Perceptive and motoric activities and formation of representations via interiorization of practical doings** and
2. **Abstraction and generalization** (rejecting unimportant, generalization).

In the practical sense this learning presupposes adequate structure and equipment of preschools that will be direct children's surroundings and provide children with the optimal conditions and stimuli in order to achieve their practical and thinking activity. On the other hand they must response to those quantitative and qualitative sensory stimuli what may provide a stimulating learning environment.

2. "Cubes" – the look and characteristics

The name of the didactic means – toys: "**Cubes**" (picture 1).



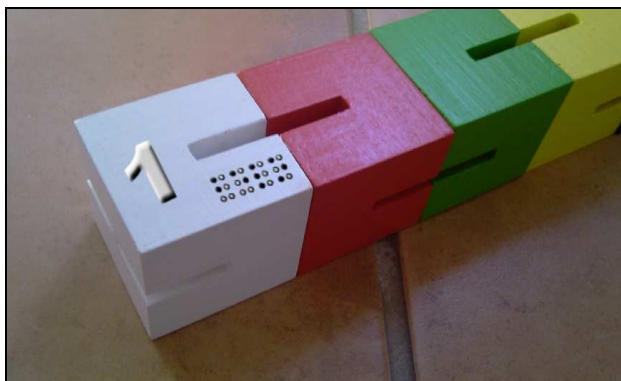
Picture 1. Prototype of didactic and manipulative means “Cubes”

Characteristics of toys:

- The number of cubes in a sequel is 10,
- Each cube dimensions are 5 x 5 x 5 cm,
- Cubes can be moved and turned over in all three directions and they are interconnected by elastic tape inside the cubes, length 6 mm,
- Cubes are made of natural material, wood (beech, because it is hard, easy to process and can be painted well) and
- Cubes are painted with ecological paint that is not harmful for kids.

The colors are certified according to the standard **ISO 14001**.

“**Cubes**” can attribute in developing initial mathematical concepts at children who do not see well and the blind ones if it is arranged with pressed stamped numbers that can be sensed by touch and by sign of a color in **Braille letters** (picture 2).



Picture 2. “Cubes” marked by number and sign in Braille letter

3. “Cubes” – application

The activities it can be applied are the following teaching units:

1. Number 1
2. Number 2
3. Number 3
4. Number 4
5. Number 5
6. Number 6
7. Number 7
8. Number 8
9. Number 9
10. Number 10
11. Number sequel from 1 do 10
12. Numbers to 20 (using two “Cubes”)
13. Number sequel to 20 (using two “Cubes”)
14. Setting the cubes in increasing and decreasing sequel
15. Ordinal numbers
16. Forebear-follower
17. Pair-Odd number
18. Addition from 0 to 10 (using two “Cubes” to 20)
19. Subtraction from 10 to 1 (using two “Cubes” to 20)
20. Bigger-Smaller-Even

21. Lines-straight line, closed line, opened line
22. Long-Short
23. Much-Less
24. Left-Right
25. Up-Down
26. In front of – Between – Behind
27. Under – Above
28. Big-Small
29. Thick-Thin
30. High-Low
31. In – On – Out
32. Below – On
33. Near – Far
34. Inside – Outside
35. Forming agglomeration
36. Geometrical body – cube
37. Geometrical body – rectangle
38. Geometrical figure – square
39. Geometrical figure – rectangle
40. Right angle
41. Agglomeration
42. Agglomeration serial
43. Colors
44. Serial of colors
45. Acquiring concepts of whole and a half
46. Length – meter (using two “Cubes”)
47. Measuring lengths
48. Closed and opened line
49. Forming the letters (I, L, S, U, O)
50. Forming the numbers (0, 1, 5, 6, 9).

4. “Cubes” – what else?



“Cubes” is didactic and manipulative means that was invented by the students of the generation 2010/11 for the subject **Methodic of the development of the initial mathematical concepts**. It appeared looking up to the didactic material produced by Maria Montessori. During the whole semester of 2012/13 we worked on final modeling and application of “Cubes” in educational work in kindergarten. Additionally in favor of this there is a survey conducted that present didactic and practical application. Students of the final year of studies and 20 preschool

teachers were involved in the preschool “Šumice” in Subotica. The result support the positive attitude of the participators in the survey who claimed that is quite practical and useful in direct educational process.

There was this question: Do you think that “**Cubes**” can be applied in the one, 25 or 50 activities students and teachers agreed in 95%, that is 114 of them claimed that is applicable in 50 units whilst only 5% claimed that it can be applied in 25 units.

Whether you would use “**Cubes**” in your work or in your future work 120 examinees positively claimed regarding its utility.

In the following questions the absolute consent of the examinees was gained regarding that:

- 1) “**Cubes**” presents stimulation and simple means in the process of acquiring knowledge related to the beginning development of mathematical concepts;
- 2) “**Cubes**” stimulates manipulative skills of hands and development of fine hand motoric;
- 3) “**Cubes**” expands experiences in adopting spatial relations and functional thinking;
- 4) “**Cubes**” would recommend to the colleagues or parents of preschool children;
- 5) “**Cubes**” does not represent only one more marketing means in the flood of big and aggressive campaign of poor and harmful educational materials that are offered to preschools without tests, check or expert’s recommendations.

Since we talk about prototype a new didactic and manipulative means “**Cubes**”, purposed for the children of preschools it must necessarily be put under the sequel of tests in the larger sample of a survey. Thus, we could get significant results regarding its applicability that is in accordance with the objectives of the teaching topics of Methodic of the development of the initial mathematical concepts. The objectives are: development of mental and cognitive structures, transfer of the children’s experiences into mathematical concepts about qualitative, quantitative and space-time relations and stimulating the development of motor capabilities or manipulative skillfulness of hands, as well.

During the further research we have to establish the following:

- 1) Whether this didactic and manipulative means “**Cubes**” effects the increasing level of knowledge at children,
- 2) Whether manipulative activity with “**Cubes**” in work contributes to the development of manipulative capabilities of children’s hands and
- 3) Whether the application of didactic and manipulative means “**Cubes**”, contributes the elevation of achievement motives at children’s work.

Alongside the research model, auxiliary hypothesis and basic grounds would be defined in order to establish whether:

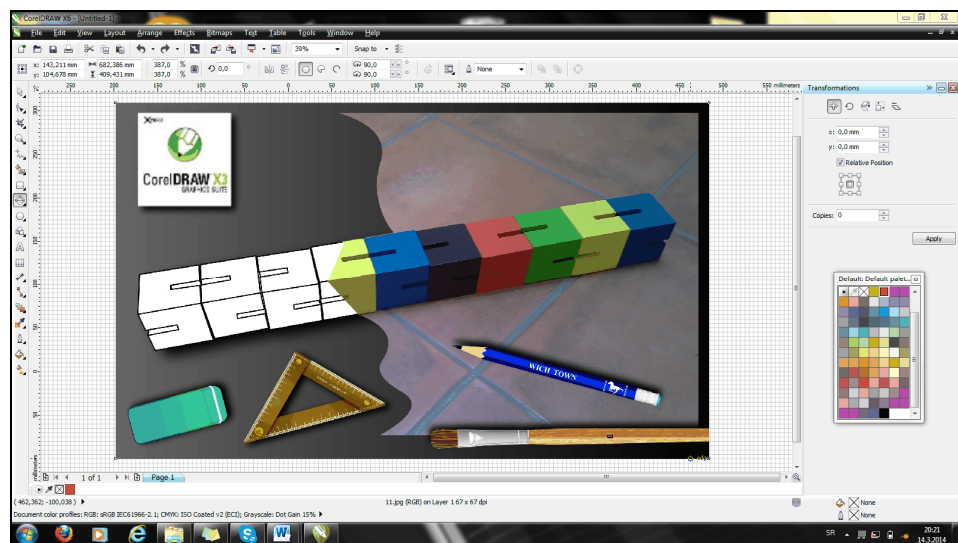
- Application of innovative didactic and manipulative means “**Cubes**” has a statistical significance onto increasing the educational objectives in class

works of the subject Methodic of the development of the initial mathematical concepts, that

- **H1** represented didactical and manipulative means “Cubes” effects level of knowledge by increasing it, that
- **H2** represented didactical and manipulative means “Cubes” effects positively development of skills and motor capabilities that is manipulative skillfulness of children’s hands in space (in three ambles) and that
- **H3** represented didactical and manipulative means “Cubes” contributes increase of achievement motives in children’s work.

Techniques of research would be a survey (questionnaire), knowledge test and ability test with measuring instruments:

- a) Knowledge test,
- b) Measuring instrument for the assesment of motor abilities or manipulative capabilities of children’s hands (Lafay, picture 3) and
- c) Questionnaire referring to the achievemnt motif.



Picture 3. “Cubes” is projected in the graphic application COREL DRAW

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Abstract

For the purposes of the academic course entitled Methods of Initial Formation of Mathematical Concepts, we created a didactic and manipulative product “Kockalica” (cubes) which is applicable in about 50 school lessons. These findings have come out as a result of numerous submitted seminar works, prepared teaching resources, activities and simulation tasks developed by students of College of Vocational Studies in Subotica. During the implementation of the final exams and professional development sessions in kindergartens, this didactic resource has been implemented in a number of educational topics. The conducted survey, developed by our students and kindergarten teachers, indicates the usefulness and applicability of “Kockalica” (cubes) in the acquisition of mathematical concepts in children of this age. In the process of shaping of this simple and widely applicable teaching resource, Braille script has been carved onto the surface, making it more accessible for visually impaired and blind children. The aim of the paper is to present an innovative teaching resource “Kockalica” (cubes) to a wider range of potential users and practitioners.

Key words: The initial formation of mathematical concepts, kindergartens, didactic, manipulative and classroom teaching resource, a wide range of applications.