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Technology for the Development of Thinking of Preschool Children and Primary School Pupils

Michael DOLINSKY

Department of Mathematics, Gomel State University "Fr. Skaryna"
Sovetskaya str., 104, Gomel, 246019, Republic of Belarus
e-mail: dolinsky@gsu.by

Abstract. This article describes an elaborated technique for creating computer exercises that were used to diagnose and develop thinking and learning skills of hundreds of scholars of Gomel and Gomel Region at Distance Learning Belarus site (`http://dl.gsu.by`).

The exercises consist of basic intellective operations that can be classified into 5 groups: operations with pairs; operations with sets; operations on a set; Boolean operations; complex operations.

Keywords: children's thinking, preschool, assessment, training, computers.

1. Introduction

Early childhood development is under permanent analysis. Among the most interesting aspects of the analysis are curriculums, challenges of evaluation (Lia and Wongb 2008), thinking and mathematics as the main results of preschool education (Aubrey, Ghent, and Kanira 2012); pro and contra using of computers (Howard, Miles, and Rees-Davies 2012); preschool-home cooperation, active learning.

This article describes the theory and practices of all these aspects in the author's project. For many years the author was engaged in training Gomel's schoolchildren for programming contests. The training is supported by the computer learning site (`http://dl.gsu.by`, further DL) created by students of the mathematical faculty of the Gomel Fr.Scaryna State University under the direction the author (Dolinsky M., 2012). Over the years the training was started at increasingly early ages; from the year 2007 it has begun with first grade. Quite effective teaching system had already been developed by that time. However the author began to think, WHY does the progress vary so much among children having the same good teaching system the same motivation and identical investment of time for training? The author came to the following conclusion: the problem is that the pupils have different initial thinking ability. Basic DL exercises relay in a substantial degree on pupils' skills to compare, analyze and draw conclusions. But the pupils are so differently skilled in thinking that this is the fundamental factor in their advancement speed in the curriculum. It turns out that it is more advantageous to precede programming training with preliminary training of general thinking skills. But how to diagnose and develop thinking? What components do thinking consists of? Finding an-

swers to these questions helps to develop the exercises specially aimed at levelling each of these components. For the "components of thinking" the author uses a term "Basic intellective operation".

The author aimed to develop a practical set of basic intellective exercises that can be integrated in the DL system to provide multitude of operating advantages including effective simultaneous training of many pupils by single teacher, accessibility both from school and home, accumulation of training results and subsequent statistical analysis.

Section 2 introduces "Basic intellective operations". Section 3 describes obtained results. Section 4 contains conclusions.

2. Basic Intellective Operations

The author distinguishes the following set of base intellective operations:

- Operations with pairs: comparison, rearrangement, association.
- Operations with sets: union, intersection, subtraction.
- Operations on a set: classification, structuring, generalization.
- Boolean operations: negation, conjunction, disjunction, equivalence, implication.
- Complex operations: synthesis, memorizing, analysis, imagination, analogy, abstraction, positioning.

Then follow descriptions of the proposed base intellective operations that also allow the selection of exercises for their diagnostics, development and control. Also provided are concrete exercise examples that are based on operations with pictures and don't require ability to read. It allows the user of exercises with wide age range starting from preschool children.

Obviously, it is difficult enough to select exercises that develop or diagnose selected single base intellective operation separately. At the same time, it is possible to select exercises having one of the base intellective operations dominant. In addition, the author promotes a concentric training plan when exercises are also split by the levels of complexity. At the beginning all base intellective operations are included at the first level of complexity, then goes the second level and so on.

Operations with Pairs

Comparison of two or more objects to find differences or the same parts.

For example:

- Select given picture.
- Put a picture on the same picture (then both disappear).
- Find the differences between the left and the right pictures.

Rearrangement of several objects (pictures, letters, words) to position them in some special order (by colour, form, size).

For example:

- Transposition of numbers in ascending or descending order.
- Transposition of triangles in order of size growth.

Association – to specify a some kind of relation.

For example, for some pictures:

- «Whose kid?».
- «Whose house?».
- «Professions».

Operations with Sets

Union of elements of source sets.

For example:

- There are given some pictures presenting two sets of objects.
- There is an outlined area where it is required to copy pictures making the union of two sets.

Intersection of elements of source sets.

For example:

- There are given some pictures presenting two sets of objects.
- There is an outlined area where it is required to copy pictures making the intersection of two sets.

Subtraction – the set of elements from the first set that are absent in the second one.

For example:

- There are given some pictures presenting two sets of objects.
- There is an outlined area where it is required to copy pictures making the subtraction of two sets.

Operations on a Set

Classification – to split up the set of objects in subsets by accordance to some criterion.

For example:

- The pictures of geometrical figures (triangles, squares, circles of different colours and sizes) are given.
- It is required to move figures into corresponding areas.
- Triangles into one area, squares into another area, circles into the third area.
- There are also similar exercises with classification by colours and sizes.

Structuring – to point hierarchical order of components of some system.

For example:

To place white and black complete sets of chess figures on a board.

Generalization.

For example:

- A picture of a strawberry is shown in the left part of the screen and there are six pictures of mushrooms, berries and flowers in the right part of the screen.
- It is required to select the pictures with berries.

Boolean Operations

Negation – to form the object that is negation for given object.
For example:
To repaint black squares into white and vice versa.

Implication – to find cause-and-effect relation for several events or facts.
For example:
Girl watering potted plants - beautiful flowers grown in pots.

Conjunction.
For example:
To bring into the indicated area only red squares. (Red and Squares).

Disjunction.
For example:
To bring into the indicated area all red figures or squares. (Red or Squares).

Equivalence.
For example:
To bring into the indicated area all the red squares and also neither red nor squares (Red & Squares or Not Red & Not Squares).

Complex Operations

Synthesis – to collect unit from parts.
For example:
Gather a picture from separate fragments.

Memorizing – it is required to reproduce something shown before.
For example:

- The picture is shown for 10 seconds and then four similar pictures are presented.
- It is required to choose the initial picture.

Analysis – a unit is offered, it is required to find out what parts this unit consists of.
For example:

- There are pictures of a marble, a helicopter, a bicycle and a penguin in the left side, each coloured with three pencils of different colours.
- There are pictures with triples of colour pencils on the right side.
- It is required to pick up the pencils that match the colours on the picture.

Imagination – a part is offered, it is required to imagine the whole.
For example:

- The picture is given with cutted part and few parts.
- It is necessary to choose the cut part from these few parts.

Analogy – implementation of some set of actions forming a result “by analogy”.
For example:
Various IQ-tests-like exercises.

Abstraction.

For example:

- There are some pictures.
- Pupil needs to choose mathematical abstraction for them (point, line, polygon, curve).

Positioning – mark the defined part of picture.

For example:

- There are left and right squares ruled into cells.
- The question character appears in the some cell of the left square.
- It is needed to select the same cell of the right square.

During the elaboration of base intellective operations and the exercises there were also concurrently created convenient applets for visual design of such exercises. One of the main requirements for such tools was minimal level of computer literacy requirement for users. As a result, the exercises can be created not only by teachers and students, but even by pupils of seventh, fifth, third and even second grades.

3. Application Results

The electronic course "Learning to think", containing exercises for the basic intellective operation development, was introduced in September 2008. It was used by 156 scholars from Gomel and Gomel region in the 2008–2009 academic year. The number of users increased to 737 scholars and teachers in the 2009–2010 academic year, including all pupils of 1–3,5 grades of Gomel school 27. As a result, the course was completed by 49 pupils of the 1st grade, 67 pupils of the 2nd grade, 54 pupils of the 3rd grade and 55 pupils of the 5th grade. The minimal, maximal and average time spent on doing the exercises of the course is given below (Table 1).

Comparing minimal, maximal and average times on different grades, we can see essential difference between the first and second grades and almost no difference between the second and next grades. The conclusion is that learning in the first grade significantly increased the thinking skills of most pupils. Another important observation is the strong differentiation in the training of pupils that remain at higher grades: the strong pupils do progress three times faster than the weak ones, both in the first grade and in all subsequent grades.

Table 1

Time spent doing the exercises

	1 grade	2 grade	3 grade	5 grade
Minimal time	10:26	05:32	05:53	05:41
Maximal time	33:02	18:40	18:42	16:54
Average time	17:34	11:16	10:10	09:24
Number of pupils	49	67	54	55

4. Conclusion

The main conclusions are:

- The learning process develops thinking possibilities mostly at first grade.
- Strong differentiation in the progress of pupils, which is discovered in the first grade, doesn't disappear during transition of pupils from grade to grade.
- The results of the best and the worst students increasingly differ as exercises become more complicated.

These conclusions gave birth to strong doubts about the effectiveness of joint teaching of so differently advanced pupils. To solve the problem, author proposes to use the described exercises for computer-based testing of pupils before enrolling the first grade. In case of poor test results, infants with their parents should be recommended to attend to an additional one-year "pre-school" training with described exercises, which may be sufficient to align the skills of mental activity and highly raise chances of subsequent successful learning.

References

Aubrey, C., Ghent, K. Kanira, E. (2012). Enhancing thinking skills in early childhood. *International Journal of Early Years Education*, 20(4), 332–48.

Dolinsky, M. (2013). An approach to teach introductory-level computer programming. *Olympiads in Informatics*, 7, 14–22.

Howard, J., Miles, G., Rees-Davies, L. (2012). Computer use within a play-based early years curriculum. *International Journal of Early Years Education*, 20(2), 175–89.

Lia, H., Wongb, N. (2008). Implementing performance indicators of early learning and teaching. *A Chinese Study International Journal of Early Years Education*, 16(2), 115–31.

M. Dolinsky is a lecturer in Gomel State University "Fr. Skaryna" since 1993. Since 1999 he is leading developer of the educational site of the University dl.gsu.by. Since 1997 he is heading preparation of the scholars in Gomel to participate in programming contests and Olympiad in informatics. He was a deputy leader of the team of Belarus for IOI'2006, IOI'2007, IOI'2008 and IOI'2009. His PhD is devoted to the tools for digital system design. His current research is in teaching Computer Science and Mathematics from early age.