THE FRONT- SIDE- AND TOP-VIEW OF AN OBJECT

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Abstract: *In this paper we describe a teaching experiment on drawing different views of an object. This topic is in close connection with the field of spatial orientation. We investigate some exercises prepared for second graders (age 7-8), and draw some conclusions about developing pupils' competence in this area through classroom practice.*

INTRODUCTION

This study is part of a research on spatial orientation competence in primary school.
Spatial orientation describes the visualization of a spatial arrangement in which the observer is part of the situation (Maier, 1999).
On the basis of mathematical and historical analysis we may divide the relevant mathematics curriculum regarding the topic of spatial orientation into 6 subtopics (Kónya, 2006).

- Using words to describe spatial relations
- Describing routes (using simple maps)
- Ordering cyclically
- The coordinate system
- Geometrical transformations
- The front-, side-, and top-view of an object

We will discuss the particulars of the thinking process and typical difficulties connected to the 6th subtopic.

THEORETICAL BACKGROUND

We use Guilford's interpretation of spatial ability, especially spatial orientation. Spatial ability has two main components: visualization and spatial orientation. Spatial orientation has five components: factor S3 of Thurstone, spatial relations, spatial perception, mental rotation and kinesthetic imagery (Maier, 1999).
Visual perception is an important precondition of the development of spatial ability. Forstig and Hoffer describe perception of spatial situations as one of the fields of visual perception (Franke, 2000, p. 38-43). This is the case of relations between an object and its perceiver.
We studied the results of mathematic didactical theories connected to the ability of spatial orientation. Our analysis is based mainly on the work of Freudenthal (Freudenthal, 1983) and Piaget (Piaget, 1970).
The precondition of spatial orientation is that we are able to orientate on our body and in relation to our own body. Using words of spatial relations (linear polarities) is unambiguous if we determine the relating point. We can relate the position of an object to our body (to the observer) or to another object. Learning of concepts of directions (*left* side-*right* side, *front-back*, *bottom-*

top) is less difficult than learning the analogous relations (*left-right, in front of-behind, below-above*).
When we construct different views of an object we experience the nature of linear order and linear directions too.
If we want to represent a spatial object in the plane, we can draw it from different viewpoints. The picture depends on the relation between the place of the object and the place of the observer.
"In order to attain an intended relation between an object and its perceiver or manipulator, there is a choice between change of place of object, and opposite change of standpoint, and such a relation can be maintained by change of place of one of them and a corresponding change of the other." (Freudenthal, 1983, p. 293)
Drawing the *front- side-* and *top-views* of an object creates a connection not only between visualization and orientation, but between plane and space geometry too.
The process has two directions: drawing different views of a spatial object or constructing an object with the help of its *front- side-* and *top-views*.

RESEARCH QUESTIONS AND METHODOLOGY

Our research questions are the following:
1. Do pupils in grade 2 have the competence to create views of an object from different directions?
2. Can they recognize if there is more spatial construction to a given view?

We assumed that in this age it is worth dealing with these questions through specific activities.

Our investigation consists of the following phases:
• We planned a pilot study with pupils of grades 1-4. Our goal was to gauge the problems of elementary school-pupils in different ages in order to adjust the actual knowledge level for the full experiment. We chose three elementary schools in Debrecen, in Hungary. We also chose three classes from every grade. The classes were without any specification, their learning based on the normal curriculum of their school. The composition of the pupils participating in our experiment was chosen to represent the real situation in the grades 1-4 in Hungary.

Grades	Grade 1	Grade 2	Grade 3	Grade 4	All
Number of participants	63	78	73	62	276

Table 1

After this pilot study we carried out a classroom experiment with pupils of grade 2 (7-8 years old children). We chose 27 pupils who were first graders in the training school of the teacher training college at the time of our pilot study. Our aim was to try our ideas to develop pupil's ability in the field of spatial orientation. Grade 2 seemed a good choice because pupils are already familiar with school life, reading and writing.
We planned the lessons together with the classroom-teacher, and discussed the problems after the lessons, but we did not teach.

RESULTS

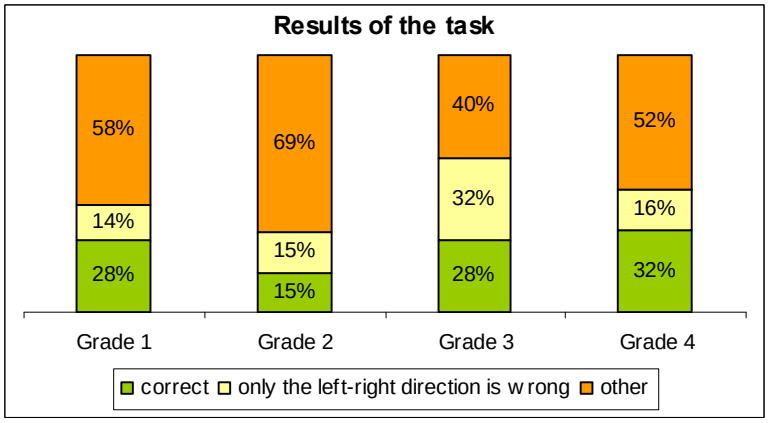
Pilot study

We prepared the following paper-pencil task:
The photos of the cup were taken from the front, back, left and right side. Write down the direction from which the photo was taken if we know that the first photo was taken from the front!




front

We can visualize the process in two ways: The observer went around the cup or he/she turned the cup around and took the 4 photos. Both situations refer to rotation around an axis by 90°. To solve the problem pupils should imagine the spatial movement, the result of this movement and relate it to a picture in the plane. *Picture 1* show an overview of solutions.



Picture 1

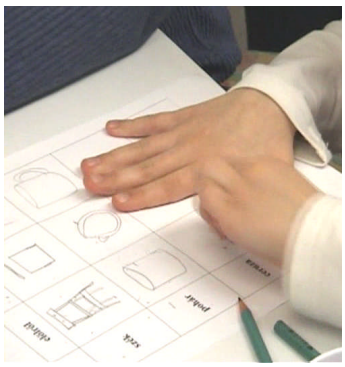
- There were pupils who disputed the statement that the first photo was taken from the *front*. Maybe they do not feel that the choice of the first direction is arbitrary. They indicated "f*ront*" mainly on photos 4 or 2.
- Mixing up the *left* and the *right* sides was also a typical problem. These pupils probably could not decide whether they should relate to their own body or to the cup.
- The number of good solutions was very small in every grade (*Picture 1*). We can conclude that pupils were not familiar with such kind of tasks.

Teaching experiment

In the teaching experiment with second graders we prepared 3 problems in 3 different lessons.

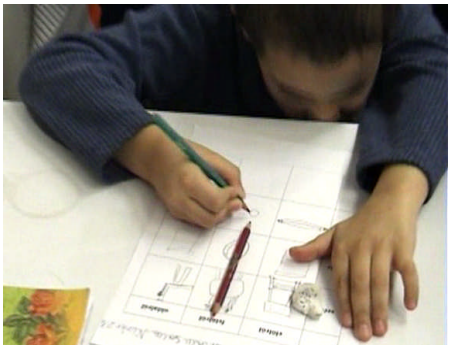
Problem 1

Pupils had to draw *front-*, *top-* and *side- views* of well-known objects. Based on the results of the pilot study, we chose objects whose *left* and *right sides* were the same: a chair, a glass and a pencil.
The views of the chair were drawn with the guidance of the teacher, while the others were drawn alone.
Unfortunately, the explanation of the teacher was not precise enough. She explained the views in the following way: the *front-* and *side-views* with turning the chair, but the *top-view* was shown by asking a pupil to stand up and then asking him to view the chair *from above*. Thus we were not consistent, and probably this was one of the reasons for confusing the different views of the objects.
The main problems with drawing the views were the following:



Picture 2

- The pictures were too detailed. Pupils wanted to draw all the small, unimportant parts (screws, holes …).
- They wanted to draw in perspective instead of drawing schematically (*Picture 2*).
- When drawing the pencil, we found new difficulties: the starting position of an object determines the other views. (*How do I have to hold the pencil?*)
- We saw pupils who changed their position between drawing two views. For example Nizar drew the *front-view* so that he stood his pencil up, but he drew it rotating by 90°. He drew the *top-view* so that he looked at his pencil *from above*, then laid it down and looked at it *from the front* (*Picture 3*). When drawing the *side-view* he looked at the pencil from the *right* and drew it again rotating by 90° (*Picture 4*).



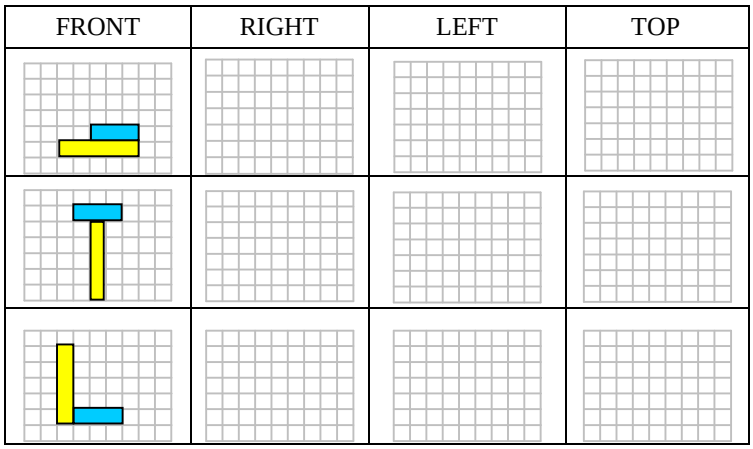
Picture 3

Picture 4

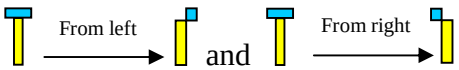
- Most problems arose from the wrong interpretation of the relation of the object and observer.

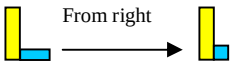
Problem 2

Based on the experience of the first task, we prepared a new problem.
We created a simpler object with two colored sticks (The length of blue stick was 3 cm, the yellow was 5 cm.)



First pupils had to build the object known *from the front*, than draw the other views.

- The first object was made together with the teacher. After the instruction: "*Put the two sticks down so that from the front they look exactly like on the picture!*" 8 pupils assumed that the first picture is the *top-view*.
- They discussed whether the *left* and *right views* are the same or not. *"A little bit different..."*, *"It is farther…"* But they did not understand that in case of an object perpendicular to the plane the views of the position are indifferent.
- As a consequence, we found the next typical mistake: 

- By the third object the most frequent fault was: 

In this case more then one spatial arrangements were possible, but no one recognized this.

Problem 3

In the third lesson we continued the construction of objects from colored sticks. We gave the *front-views* as follows: 1.  2.  3. 

Most mistakes arose from the same problem as in the second lesson. Here it was possible to find more solutions, but second graders did not recognize this fact. The last task was to build an arbitrary object and create different views. Pupils enjoyed it and solved the problem with creativity.

CONCLUSION

- Pupils of grade 1-4. did not deal with such kind of questions as *How does an object from a certain point of view look like?*
- In case of simple arrangements (2-3 elements) we can start to teach the constructions of the *front-*, *side-* and *top-view* already in grade 2.
- These activities happen parallel on the enactive and iconic planes and contribute to the understanding of spatial relations, the use of linear polarities in an appropriate way.
- Most pupils had no problems distinguishing directions, but they did with questions arising from practice (e.g. the object and the observer move related to each other). The many questions suggest that it is worth using the method of individual development instead of methods of frontal or isolated teaching.

- Pupils understood the essence of the drawing method, but they recognized only one possibility of building up a certain arrangement.
- The construction of views of an object does not develop spontaneously. We can start the developmental process in grade 2, but we must continue over the subsequent years.

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