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CONCEPT DEFINITION AND CONCEPT IMAGE OF BASIC SPATIAL GEOMETRY CONCEPTS AMONG JUNIOR HIGH-SCHOOL PUPIL

Shaker Rasslan, & Samaher Zoabe
Department of Mathematics Education, Al-Qasemi -Academic College for Education (Israel)

Abstract

The main goal of this study was to discover the effect of visual elements on the students' geometrical concept formation. This study focused on three topics: visual knowledge, concept definition, and concept image, and the inclusion property for spatial shapes among middle school students. Five research questions arose: (1) To what extent did the visual knowledge of spatial shapes exist? (2) What are the concept definitions of central spatial geometry shapes that middle school students gave? (3) What are the main concept images of spatial geometry? (4) To what extent does the relation between the visual picture of spatial shapes and the definition of such shapes exist? (5) To what extent did the inclusion property exist in spatial shape groups? The editors compiled three questionnaires and analyzed the data based on cognitive methods (Tall &Vinner, 1981). According to question (1), the data analysis showed that between 53.4%-95.5% of our sample knew visually the spatial shape (Triple Pyramid, Con, Box, Cylinder, respectively). According to question (2), it turns out that ONLY 46.1% of our sample correctly defines the concept "spatial body". Data analysis according to question (3) showed that the main concept images of "spatial body" were: a polyhedron, a beautiful shape, and a tangible body. According to question (4), the data analysis showed that the relation between the visual picture of a spatial shape and its definition was low to very low and depended on the shape: 21.2%- 61.1% (Prism, Cube, Pyramid, Box, respectively). Such students recognize the shapes without any inclusion relationship to other groups of spatial shapes. According to the last question (5), it turned out that the inclusion property existed visually in spatial shapes, but in different percentages according to the shape (Box, Cube, Pyramid, and Prism). It is surprising that when the statements were given to the students verbally without a visual dimension, more students identified the inclusion relationships accurately and even knew how to explain them. In many cases, the visual properties affect the students' judgment and the classification they make. When the task is represented verbally, these properties are hidden, but when the task is represented visually these properties visually these properties become active. In summary, we have found that a low and even very low percentage of students know the formal definition of spatial shapes but do not make use of it when faced a visual presentation.

Keywords: *Concept definition, concept image, concept formation, spatial shapes.*

1. Introduction

Geometry is one of the important branches of the mathematics curriculum, as it constitutes an important and vital part, as it constitutes a model and a real link to mathematics with the real world because of its association with the ability to think, and it is a vital and enjoyable subject in its characteristics, as it is related to the reality of life, and occupies an important space in the study program for all stages of education from kindergarten to twelfth grade (Usiskin, 1997).

All mathematical concepts except the primitive ones have definitions. Many of them are introduced to high school or college students. However, the students do not necessarily use the definition to decide whether a given idea is or is not an example of the concept. In most cases, they decide based on their concept image, that is, all the mental pictures, properties, and processes associated with the concept in their mind. (Tall & Vinner, 1981; Rasslan & Vinner, 1997).

Through the experience of the author of this project in teaching mathematics in primary and preparatory schools, and through her study of the master's degree in educational mathematics, she found that there are many difficulties in teaching and learning geometry for students and teachers alike. Her readings of literary narrative related to teaching and learning geometry and the difficulties she herself faces in the field, and mentioned in the literary narrative proved this. What was said earlier was true for planar geometry. As for spatial geometry, the experience of the author of this project also indicates many difficulties in teaching and learning this subject. Due to the lack of literary narrative in teaching and learning spatial geometry in general and in the Arab sector in particular, the author of this project, in coordination with the project guide, decided to examine the extent to which these difficulties exist in Arab schools. Specifically, examine the understanding of central terminology in spatial geometry among middle school students.

Important studies in this context are those of Haj Yahya and Hershcowitz (2013), where these researchers examined the relationship between visual comprehension and its effect on mental images, definitions and proofs of forms in plane geometry among secondary school students. It was found that these students have great difficulties in understanding geometric definitions, which affects the proof process and thus the ability to demonstrate.

2. Research questions

To what extent the inclusion property existed visually in spatial shapes (Box, Cube, Pyramid, and Prism)?

3. Methodology

This study was designed using a quantitative method.

3.1. Participants

The study sample consisted of 90 seventh-grade students from four schools in the Arab Sector: two from the Murooj region and two from the north of Israel.

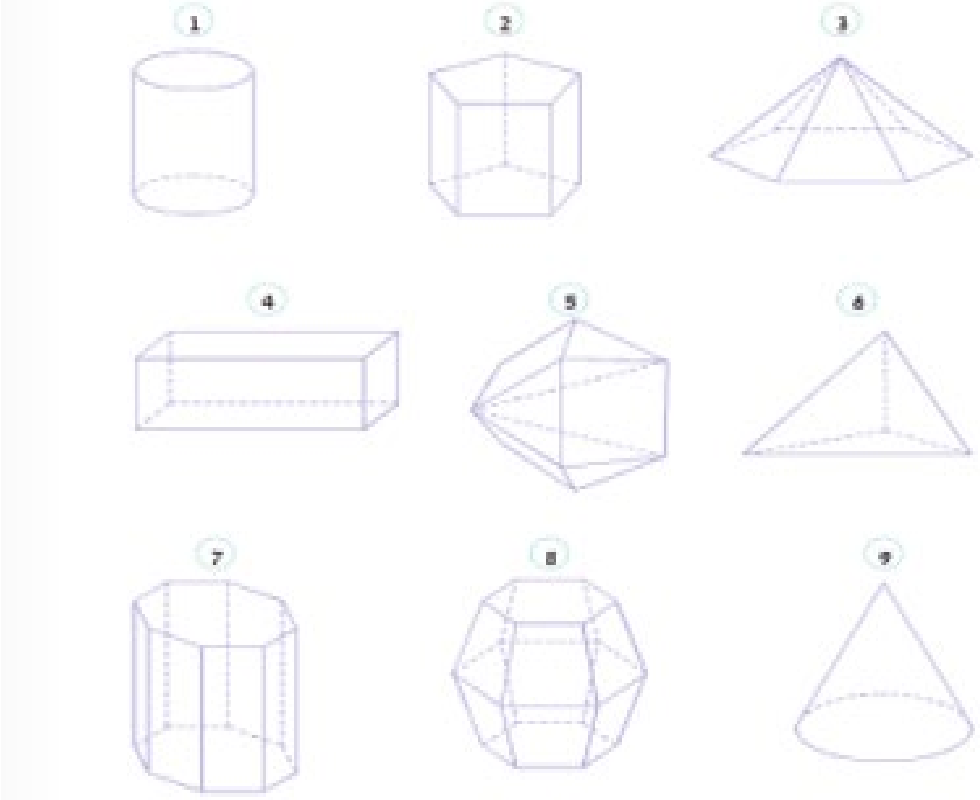
3.2. Instruments

In this study, the following instruments were used:

1. A questionnaire (Figure1) related to the “length measurement” content. The questionnaire aims to get a real picture (through the students' answers) to answer the research questions.
2. A semi-structured interview. The interviews aim to clarify vague answers that were not clear enough, as they were received through the answers of some students, as contained in the various forms.

Figure 1. The Questionnaire.

Student Name: _____ Grade: _____ School: _____
Gender: Male/Female
In front of you a group of shapes:



1) Record shapes representing a box: _____
2) Record shapes representing a pyramid: _____
3) shapes representing a prism: _____
4) Record shapes representing a cube: _____

4. Results

In the following table we will present the distribution (number and percentage) of the answers of the students who answered question number 1 in the questionnaire that was presented.

Table 1. Inclusion a Box in other groups of bodies. (N=85).

	Shape / Category	1 Tetra pyramid	2 Cube	3 Box	4 Polyhedron	5 Cylinder	6 Triangular Prism	7 Triangular Pyramid	8 Pentagonal Prism	Total
BOX	I		√	√						52 (61.1%)
	II		√							1 (1.2%)
	III			√						21 (24.7%)
	IV	√	√	√						1 (1.2%)
	V		√	√						2 (2.4%)
	VI		√	√						2 (2.4%)
	VII		√	√	√				√	1 (1.2%)
	VIII		√							1 (1.2%)
	IX								√	2 (2.4%)
	X								√	2 (2.4%)
Total		1.2%	70.6%	92.9%	1.2%	2.4%	2.4%	4.7%	7%	85 (100%)

It is clear from Table 1 that the overwhelming majority of students participating in the sample of this research 92.9% diagnosed the box correctly, but only 24.7% (category III) had diagnosed the box without any relationship containing other models.

Similar analysis according to questions 2, 3, 4 in the questionnaire 1 (pyramid, prism and a cube respectively) the results show that (94.1%, 70.5% and 95.3% respectively) diagnosed them correctly, but only 16.4%, 25.9% and 63.5% respectively) without any relationship containing other models.

5. Discussion

This article discusses five research questions presented in the abstract. An analysis of the results of the questions clearly shows that the percentage of correct answers to the five questions was low, and some of them were very low, especially in question 2, where it turned out that only 46.1% of all the students who participated in this study correctly defined the concept of "spatial body".

In the present article, we focused on a question related to the "inclusion property", in particular, on the question:

To what extent the inclusion property existed visually in spatial shapes (Box, Cube, Pyramid, and Prism)?

The results shows that only 24.7% had diagnosed the box without any relationship containing other models. The rest, which is 75.3% of the responses of the students who participated in this study, associated the Box with the other bodies: Cube, Pyramid, and Prism. This result is also considered low.

In our opinion, the reason for the unsatisfying and very low results of the students in our sample of both the five questions and the last research question is probably related to each other, i.e., to the definitions of these concepts and the concepts images discussed in this study and to the learning and teaching spatial shapes.

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