ROLE OF SYMMETRY AXES ; UNDERGRADUATE STUDENTS' EXPERıENCE OF ıMPOSSıBLE FıGURES WıTH MANY MODULES

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With the 2005 curriculum, geometry teaching in the secondary grades asks for reasoning with various diagrams. Impossible figures are such kind of diagrams that enables students to see reflection with respect to many symmetry axes at once. This adds a new type of complexity to the geometrical thinking and reasoning. In this study, five types of impossible figures were used to gather data on students' number of corrections and the time asked for completing this, affected by 2, 3 and 6 modules and figure type (hexagonal symmetry I, II, III, line symmetry and triangle symmetry-II). MANOVA analysis of variance concluded many interesting associations regarding the model and the role of the symmetry axis on students' answers.

TRANSFORMATIONAL GEOMETRY AND IMPOSSIBLE FIGURES

Recent curriculum for middle grades consists some new mathematics content such as transformational geometry. Students need to see and understand reflection, turning, transition. Especially, reflection with respect to different symmetry axes is an issue. Students need to predict the new position of parts of the figures.

An impossible figure is a three dimensional geometrical shape which has some dimension quality inside but lacks real existence. Complexity theory states that learning is a complex entity that uses diagrams and figures, and reasoning with them. One can say that any perspective to analyse students' learning of transformational geometry would be a necessity for the new era.

The impossible figures used in this study are hexagonal symmetry-I, II, III, line symmetry, and triangle symmetry-II. I, II, and III stands for different types of symmetry axes.

Table 1. Impossible figures used in the study

Impossible figure type	module	difficulty	Axes of reflection
hex-symmetry-I	6	2	6
hex-symmetry-II	6	1	6
hex-symmetry-III	6	2	6
Line symmetry	2	2	2
Triangle	3	2	3

symmetry-II			

Method and data collection

Time was asked as students' own perception in minutes. Corrections were numbered as could be seen from the paper. The format of the papers were a small version of impossible figure up in the paper and a dotted empty part in which students regenerated the upper figure to the fullest possible way without a correction. They were not told about their corrections would be counted. They were only told that this study could be a part of the study on geometrical thinking and reasoning which is aimed to be. Data was collected from three universities from a 10 year period. Students were undergraduate students mostly preschool teachers but with some engineering students as well.

Data analysis

Data was analysed with SPSS 17 statistical package. The model to begin with was two independent variables: figure type and modules; and two dependent variables: time and number of corrections. MANOVA analyses revealed that although that model is predictory, module and fig type vs. module were not explaining the dependent variables. Some sub categories of the cross tabulation gave interesting results, such as some significant differences between hex-symmetry-I, III and II, and with line symmetry and others.

Study will be used to flourish some new areas of thinking on students' reasoning with different symmetry axes. It may give some insight to spatial thinking and reasoning as well.

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