

THE EFFECTS OF VIRTUAL AND PHYSICAL MANIPULATIVES ON STUDENTS' SPATIAL VISUALIZATION SKILLS

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1. INTRODUCTION

Spatial ability has been an interest of humankind since Galton's systematic psychological inquiries. He founded the field of enquiry, Differential Psychology, which concerns itself with psychological differences between people, after psychological inquiries. The first studies in the field of spatial ability dates back to the 1940s in the mathematics education literature. However, the concept was also interest of psychologists a decade earlier.

Many terms have been used in the literature related to spatial ability. Spatial skills, spatial perception, spatial reasoning, and spatial sense are all terms that describe similar process (Bishop, 1983; Wheatley, 1990; NCTM, 2000). Although there is a large body of work on spatial ability, there is not a common consensus for the terminology used in this field and an agreement about spatial ability's elements. Various authors including psychologists and educators have identified distinct components of spatial ability. According to McGee (1979), spatial ability consists of spatial skills as changing, rotating, bending and reversing of an object presented for stimulating in the mind. Linn and Petersen (1985) define spatial ability with mental processes being used in perceiving, storing, recalling, creating, arranging and making related spatial images. Spatial ability have identified several different spatial ability factors as understanding relations visually, making changes on shapes, rearrangement and interpreting them (Tartre, 1990).

Various authors have identified distinct components of spatial ability. In an extensive review of spatial abilities literatures, McGee (1979) concluded that the most conclusive evidence points to the existence of at least two factors associated with spatial ability; visualization and orientation. McGee (1979) summarized the spatial visualization that the ability to mentally rotate, twist, or invert pictorially presented stimulus object. The underlying ability seems to involve a process of recognition, retention, and recall of a configuration in which there is movement among internal parts of the configuration, or the recognition, retention, and recall of an object manipulated in three-dimensional space or which involves the folding and unfolding of flat patterns. McGee (1979) summarized the spatial orientation that the comprehension of the arrangement of elements within a visual stimulus pattern and

the aptitude to remain unconfused by the changing orientation in which a spatial configuration may be presented. Visualization is often differentiated from orientation by the mental process and stimulus involved. Orientation requires the mental rotation of the object as a whole (holistic reasoning) whereas visualization requires the movement of parts of the object (multi-step reasoning) (McGee, 1979; Friedman, 1990; July, 2001). The primary focus of this study is on spatial visualization. As mentioned above, spatial visualization can be described the ability to imagine the rotation of depicted objects, the folding or unfolding of flat patterns, the relative changes in position of an object in space, or the motion of machinery.

Spatial ability plays an important role in the work of various fields such as computer graphics, engineering and architecture. Numerous studies have shown that spatial ability is positively related to problem solving ability as well as success in geometry and mathematics (Fennema&Sherman, 1977; Fennema&Tartre, 1985, Moses, 1977). Battista, Wheatley, and Talsma (1982) found that spatial ability is related to achievement in mathematics. Battista (1990) found that spatial visualization and logical reasoning were significantly related to both geometry achievement and geometry problem solving. Because of three-dimensional structure of solid geometry, spatial visualization may be much more important for solid geometry.

A number of studies suggest that spatial skills can be developed through instruction (Bishop, 1980; Battista, Wheatley&Talsma, 1982; Ben-Chaim, Lappan&Houang, 1988; Travis&Lenon, 1997). Appropriate materials should be used in order to improve spatial skills. NCTM (2000) recommends that 2-D and 3-D spatial visualization and reasoning are core skills that all students should develop.

There exist different type of manipulatives used in geometry classes. Physical manipulatives are often used in classrooms to help students understand abstract concepts. When students learn about the volume and surface area of 3-D shapes, teachers often use physical manipulatives. This teaching method enables students to visualize the volume and surface area of each manipulative. However, numerous studies showed that dynamic geometry software (DGS) could be an effective tool for teaching geometry (Hannafin, Burruss&Little, 2001; Güven&Karataş, 2001), and suggests that DGS can facilitate the development of students' spatial skills (Güven&Kösa, 2008). In the mathematics education literature, DGSs have been called virtual manipulatives. There are many various DGS such as Cabri Geometry II, Geometer's Sketchpad, Cinderella, etc. Using DGS for teaching geometry provides students to make conjectures, test the hypothesises that they construct and generalize the information that they gather (Baki, Kösa&Karakuş, 2008). However, all DGSs mentioned above have designed for plane geometry, not solid geometry. The DGS Cabri3D for exploring

three-dimensional geometry promises to revolutionize computer assisted visualization and reasoning in 3-D geometry in much the same way as the earlier DGS has done for plane geometry. In Cabri3D, 3-D objects such as prism, cylinder and cone can be constructed, rotated and seen from a certain aspect on the screen and also prisms can be opened on the screen. Prisms and half plane can be intersected and thus, new 3-D objects may be formed. These features could be an incredible opportunity for the students to develop their spatial skills.

In this present study, the effects of virtual and physical manipulatives on students' spatial visualization skills will be investigated. It is aimed to determine which manipulatives are more appropriate to improve students' spatial visualization skills. Along with this aim, two curriculums are designed which one of them is a virtual manipulatives integrated into solid geometry, the other is a physical manipulatives integrated into solid geometry.

Problem Statement

The purpose of this study is to determine the effects on students' spatial visualization skills when they use virtual and physical manipulatives while they study 3-D geometry. Additionally, it is aimed to present whether using virtual and physical manipulatives have a positive effect on the students three-dimensional understanding levels or not. In this context, it will be tried to find answers to the following questions.

1. How do virtual and physical manipulatives integrated solid geometry curriculums provide students to improve their spatial visualization skills?
2. Do virtual and physical manipulatives integrated solid geometry curriculums make an improvement on students' three-dimensional geometric understanding levels?

2. PROCEDURE

This study is designed to determine the spatial visualization skills of high school students and investigate the three-dimensional geometric understanding levels of the students when they use virtual and physical manipulatives in their solid geometry lessons. From the point of view the research questions' natures, this research is a quasi-experimental study. In this present study, there will be three groups. One of them is the group which solid geometry course will be carried out with Cabri3D, another one is the group which solid geometry course will be carried out with the physical manipulatives, and the third one is the group which geometry course will be carried out with two-dimensional plane geometry tools such as

paper and pencil etc... The solid geometry curriculums, Cabri3D and physical manipulatives integrated curriculums have been formed.

The first goal of the study is to determine the role that Cabri3D played in the improvement of spatial visualization skill. In order to determine the spatial visualization skills of high school students and the improvement of this skill, Purdue Spatial Visualization Test (PSVT) will be used as pre-test and post-test for data collection. The test was developed by Roland Guay in 1976 and consists of 36 multiple-choice items in three sections (Developments, Rotations, and Views). Each section contains 12 questions.

The PSVT was shown to be a valid and reliable instrument in different studies. Branoff (1998) calculated the internal consistency coefficients of .82 and .80. Battista, Wheatley and Talsma (1982) administered the PSVT to 82 pre-service teachers enrolled in an undergraduate geometry course and reported a KR-20 of .80. Guay (1980) used the PSVT on 217 university students, 51 skilled machinist, and 101 university students on three different occasions and reported an internal consistency coefficients (KR-20) of .87, .89 and .92.

The same test will be employed as both pre-test and post-test, may be seen an important problem for the study. However, Bertoline and Miller (1990) recommended that this test can be used as pre-test and post-test to determine the spatial skills.

The second goal of the study is to investigate the high school students' three-dimensional geometric understanding levels and the effects of virtual and physical manipulatives on it. Van Hiele levels for solid geometry were characterized by Guillen. In his analytical study of college students when carrying out tasks, designed on the basis of characterization he propounded the levels of the three-dimensional geometry. In order to determine and investigate the students' understanding levels of 3-D geometry, clinical interviews will be used as he did. The results of the study will be interpreted under this framework.

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