ABSTRACT. This study presents evidence which suggests that even though students in grades 6 through 8 are familiar with a variety of types of representation modes, they have great difficulty in successfully communicating spatial information. A Building Description Task, which consists of a building made up of ten small cubes taped together and a set of instructions, was presented to a sample of middle school children. They were asked to "help your friend to know what your building looks like." Students' attempts were classified by representation mode (verbal, mixed, graphic) and analyzed by grade and by sex. In addition, the effect of instruction in spatial visualization activities on students' preference for representation mode and rate of success on the task was assessed. The findings were examined relative to the practical teaching implications, to individual differences in spatial visualization ability and to design of spatial tests.

INTRODUCTION

Gaulin (1985) discusses the need and reasons for emphasizing various types of representations of spatial shapes and relations. He stresses the need of re-establishing the development of spatial intuition as one major goal for teaching geometry and the need for emphasizing a diversity of graphical representations of three-dimensional shapes and relations.

Graphical representation of various types are commonly used in a great number of practical situations and disciplines for conveying spatial information, for example maps, diagrams, flow-charts, and scientific or technical descriptive drawings. Consequently, the ability to represent and interpret three-dimensional geometric relations is a valuable skill for many school subjects and technical occupations. Providing all pupils with opportunity to explore a variety of types of representations of spatial and geometric information, as well as to communicate such representations should be a basic educational objective.

Goodnow's (1977) book on children's drawings, however, demonstrates that children have difficulties in representation of objects. In particular, Mitchelmore (1983) points out difficulties that adolescents have in representation of regular three-dimensional figures. These include children's difficulty in representing parallel and perpendicular lines in their drawings. Bishop (1979, 1983) and Parzysz (1988) remind us that the representation of a three-dimensional object by means of a two-dimensional diagram...
demands considerable conventionalizing which is not trivial. Yet, within Western cultures, we demand such conventionalizing of young children without any attempt to directly teach conventions such as dotted lines in drawings representing unseen edges and parallelograms representing square faces in drawings of cubes. The study reported in this paper will provide evidence to suggest that: (i) middle school students, boys and girls, have difficulties in successfully representing and communicating information on a three-dimensional building made up of cubes; and (ii) instruction in spatial visualization activities, including concrete experiences with cubes, is very helpful in improving students' ability to communicate and represent spatial information.

REVIEW OF RELATED STUDIES

The skill of representing three-dimensional objects is a part of spatial visualization, which is a particular sub-set of spatial skills. Whereas one group of researchers emphasizes the mental manipulation needed in spatial visualization tasks as its main critical aspect (McGee, 1979; Fennema, 1977; Guay, 1980), another group of researchers emphasizes the need for complicated, multi-step analytic processing of spatially presented information (Linn and Petersen, 1985). Correlational and logical-intuitive arguments abound for connection between mathematical thinking and mental manipulation of geometric images (Fennema and Sherman, 1977; Connor and Serbin, 1985; Smith, 1964; Ben-Chaim, Lappan and Houang, 1989).

Spatial visualization is not one of the usual components of the school curriculum. Therefore, spatial understanding is primarily informally acquired. Nevertheless, several studies of training programs to improve spatial visualization are reported in the literature. Among them, inconsistent results are found. For example, the studies of Blade and Watson (1955), Brinkmann (1966), Bishop (1973), Connors et al. (1978), McGee (1978) and Smith and Schroeder (1979) demonstrated effectiveness of training in improving performance on spatial tests. In contrast, Mendicino (1958), Myers (1958), Sedgwick (1961), Mitchelmore (1975) and Mundy (1987) found no improvement. Hence, the question of whether students can benefit from training in spatial visualization activities is still being addressed.

In addition, the typical, but not a universal, finding, that male performance on spatial visualization is superior to female performance (Harris, 1981; Liben, 1981; Maccoby and Jacklin, 1974; Bishop, 1983) has raised more questions. Such questions are regarding the relationship between sex