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AUTHOR Fabricant, Mona
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ABSTRACT

This study was designed to assess the effects of teaching the concept of interior volume, and methods of computing this volume, on the ability of fith-grade students to conserve volume. Conservation of volume was measured by an instrument developed by Lovell and Ogilvie. Instruction was in a mode compatible with the majority of elementary textbooks. Fifty-eight fifth-grade students were paired on the basis of age, sex, and responses to pretest questions. One member of each pair was randomly assigned to instruction on volume; the other received an equivalent amount of instruction on an unrelated topic. After instruction a posttest was administered; one month later a retention test was given. Results of the experiment indicated that instruction on volume did not affect conservation by those students who gave non-conservation responses on the pretest; 50 percent of these students could reproduce the volume formula on the posttest, but less than half of these showed retention. Students who were able to conserve volume were all able to calculate volumes on the posttest, but only one-third of them retained this ability. (SD)

Mona Fabricant
134-15 231 Street
Laurelton, New York 11413
(City University of New York)

THE EFFECT OF TEACHING THE VOLUME FORMULA FOR A RECTANGULAR SOLID (v = l x w x h) ON THE LEVEL OF CONSERVATION OF VOLUME OF FIFTH GRADE SUBJECTS

A significant number of elementary school mathematics textbooks present the volume formula for a rectangular solid at the fifth grade level. Piaget et al. (1960) say that comprehension of the volume formula is attained by most children at the end of a complex process of struggling with the concept of conservation of volume, which is a developmental phenomenon occurring in the following stages: (1) conservation of interior volume, (2) conservation of occupied volume, (3) conservation of displacement volume, (4) mathematical multiplication as it relates to the measure of volume. According to Piaget, conservation of volume is a very difficult notion which cannot be fully understood until a child reaches the formal operational stage in intellectual development.. For most children this would come sometime after elementary school is completed (Piaget et al., 1960). Thus, one implication of this theory is that it would not be profitable to try to teach the volume formula, at the very least, until the subject has acquired conservation of interior volume and probably not until he is involved with resolving conflicts concerned with occupied volume.

Piaget's theory is based in large part on the premise that the stages of development occur in the order he sets down and within approximate age guidelines. Lunzer, Elkind, Lovell and Ogilvie in papers published in the early 1960's found results that were in basic agreement with Piaget. On the other hand, Flavell, Pinard and Laurendeau, and Uzgiris published articles which challenged Piaget's method of testing for conservation and consequently, his age guidelines. They concluded that conservation could perhaps be achieved at an earlier age.

While a number of variables have been examined for possible relationship to volume conservation, there has been almost no research on the effect teaching has on a student's ability to conserve volume. Lovell and Ogilvie (1961) conjectured that teaching the volume formula might help a child to achieve conservation of volume, and this position was later reiterated by Lovell in 1971. Thus, the purpose of this research was to explore whether teaching the volume formula for a rectangular solid at the fifth grade level has an effect on the development of the concept of conservation of volume as described by Piaget et al. (1960).

Subjects

Two average ability fifth grade classes at Public School 156 in Jamaica, Queens, New York City participated in this study. For the 58 subjects involved the average age was 10 years 10.5 months with a standard deviation of 3.6 months. There were no I.Q. scores available but, according to class performance, teachers rated subjects from average to slightly above average in ability.

Procedures and Methods

Lovell and Ogilvie (1961) devised a set of questions, based on Piaget's work, which were used to determine the level at which a subject is conserving volume. The experimenter used these questions to individually pretest subjects to determine their level of conservation of volume. Subjects were then paired by level of conservation, type of answers, age, and sex and then randomly assigned to either the control or the experimental group. The experimental group was taught the concept of volume and the volume formula in a method compatible with a majority of elementary school mathematics textbooks. The control group was taught an equivalent number of lessons in an unrelated topic. At the end of the lessons, subjects in the control and experimental groups were again individually tested, using Lovell and Ogilvie's technique, to determine their

level of conservation of volume. At this time all subjects were also asked if they could find a numerical value for the volume. Approximately one month later, all subjects were tested for retention of level of conservation of volume and ability to use the volume formula. Responses for the pre, post, and retention tests were taped and interpreted afterwards.

Method of Analysis of Data

The data was analyzed in three separate ways. In the first analysis, each matched pair was discussed. The changes in the experimental subject's responses were compared to those of his matched partner in the control group. The second analysis consisted of a comparison of the control group's and experimental group's responses to each of the questions used to determine level of conservation of volume. The third method of analysis consisted of the testing of the hypotheses listed below. They were tested using 2 x 2 chi-square designs.

Hypotheses

Ho:1 : There is no statistically significant relationship between teaching the volume formula for a rectangular solid to fifth grade subjects and the subject's ability to conserve volume as measured by modified Piagetian tasks (pre-post).

Ho:2 : There is no statistically significant relationship between teaching the volume formula for a rectangular solid to fifth grade subjects and the subject's ability to conserve volume as measured by modified Piagetian tasks (pre-retention).

Ho:3 : There is no statistically significant relationship between a subject's understanding of logical multiplication as measured by type of response and a subject's ability to use the volume formula after an appropriate learning experience.

Ho:4 : For those subjects who could use the formula in the posttest, there is no statistically significant relationship between his understanding of logical multiplication as measured by type of response and his retention of the formula.

Results

Following the pretest, eight pairs of subjects were identified who gave nonconservation responses to all questions, fourteen pairs of subjects who were on the threshold of conserving interior volume, one pair of subjects who gave "no clear" responses to questions concerning conservation of interior volume, and six pairs of subjects who conserved interior volume. Each pair of subjects represents a member of the experimental group and a matched member of the control group.

The learning experience seemed to have no major effect on the ability to conserve volume of the students who did not conserve volume at any level during the pretest. According to Piaget, these students had not acquired the necessary prerequisite structures for the concept of the measure of volume and therefore would not be able to grasp it. The results are in agreement with Piaget's theory. This is further illustrated in their lack of ability to learn and or retain the volume formula. Only 50% of the students retained the idea of measure of volume as the number of unit cubes and only 50% learned the formula and only one-half of them retained it.

For those students that were grappling with conservation of interior volume during the pretest, 50% learned and retained the notion of the measure of volume as the number of unit cubes, yet only 14% retained the volume formula. It seems likely that Piaget is correct in his implication that the formula would not be understood by most students until at least they are concerned with the problems of occupied and displacement volume.

For those students who could conserve interior volume in the pretest, 100% learned and retained the notion of measuring volume by counting unit cubes. This concept seems to be more closely related to the understanding of conservation of interior volume. The learning experience did not significantly affect the students' ability to conserve occupied or displacement volume. Rather, it seems likely that the ability to conserve interior volume gave them the necessary structures to assimilate the concept of the measure of volume as the number of

unit cubes. This did not, however, prepare them for retention of the volume formula. Although 100% of the students in this group could use the formula in the posttest, only one-third retained it. This differs only slightly from the other groups.

At the start of the experimental period, 76% of the experimental and 76% of the control group could not conserve volume at any level. During the posttest, 48% of the experimental group, as compared to 69% of the control group, could not conserve volume at any level. For the retention test the control group remained at the same level, whereas the experimental group went down to 45% who could not conserve volume at any level. It seems likely that the learning experience helped a few subjects to focus on the problem of conservation of volume and resolve it at some level.

There were no significant changes in terms of conservation of occupied or displacement volume. It seems likely that the learning experience had no affect on subjects' ability to conserve occupied or displacement volume

Looking at the chi-square for all the students, there is no statistically significant relationship between being tuaght the volume formula and their ability to conserve volume, in either the pre-post or pre-retention test situation. The pre-retention test chi-square was done to check on the possible statistical significance the learning experience might have over a longer period of time. Some students showed no change between the pre and post tests but did change in the retention test in ways that seemed to be related to the learning experience. For example, the counting of cubes to check on conservation of interior volume was done by some students in the retention test. For some students, the classroom experience seemed to focus their attention on the discrepancies involved but it took them a little time to resolve them.

It was noted that those students who retained the volume formula also showed ability to use logical multiplication which involves compensation of differences in the dimensions of the the object. The child takes into account

the boundaries of the surface but not in a strictly metrical or Euclidean sense. This lead to the idea that there might be a statistically significant relationship between giving answers related to logical multiplication and learning the volume formula. Although the sample size was very small, it seems important that the chi-square was significant at the .05 level. Also there were no students who gave answers related to logical multiplication and who didn't learn the volume formula for the posttest. This learning may have been partially rote or not fully digested as evidenced by the fact that for those students in the experimental group who learned the volume formula there was no statistically significant relationship between giving logical multiplication type responses and the ability to retain the volume formula. It seems that having some knowledge of logical multiplication made the initial learning of the formula easier but it was only a superficial type of learning as evidenced by the low retention rate.

Summary

Overall, the learning experience seems to have been most helpful for those students who were at the threshold of conserving interior volume. During the posttest 43% of these subjects conserved interior volume completely and of these 83% retained full conservation of interior volume in the retention test. The learning experience had no significant effect on their ability to conserve occupied or displacement volume and only 14% of this group retained the volume formula. For those who already conserved interior volume, the learning experience seemed to have little or no effect on their level of conservation of volume. It seems necessary to conclude that this type of learning experience at this grade level, was not significantly valuable for a majority of subjects who participated in this experiment. For a majority of subjects, it did not raise their level of conservation of volume.

Although it was a limited experiment done on a small scale, it does give some indication that teaching of geometric formulas the the elementary

school level has to be seriously studied to see where such formulas would be most profitably placed in the curriculum.

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