THE VALUE OF USING EDUCATIONAL AIDS IN TEACHING PLANE AND SOLID GEOMETRY

by

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Statement of the Problem

The purpose of this investigation was to determine the extent of subject matter understanding promoted by educational aids in plane and solid geometry contrasted with subject matter understanding of plane and solid geometry taught in a controlled lecture assignment type of classroom without the use of such aids.

Definition of Terms

Plane and solid geometry. Hereafter, plane and solid geometry will be referred to as geometry, since the instruction of both are correlated.

Subject matter understanding. This applies to the ability to use experiences received in geometry in forming more meaningful patterns of understanding directly related to achievement.

Educational aids. Educational aids will include all audio-visual tools and materials used in assisting and enriching the geometry textbook.

Importance of the Study

The mathematics teacher is faced with the undertaking to provide adequate understanding commensurate to the wide range of intellectual potential of his students. Many of these students find it hard to accept completely abstract ideas; they must be derived from, or illustrated by concrete examples.[1] Educational aids provide these examples as well as stimulating interest and attention.

In an article on geometric models, Grietzer said:

> There is little disputing the fact that learning can be accelerated and deepened by multisensory stimuli. While mathematics is essentially concerned with concepts and principles involving abstract reasoning, one cannot overlook or undervalue the fact that the eyes, ears, and sense of touch are the usual pathways to the mind. . . .[2]

It is the feeling of the writer that teachers need tools to do an adequate job of instruction. McCarty states:

> Teachers need tools to do an effective job. While blackboard and textbook are a substantial beginning, learning can be both accelerated and enriched when teachers have a wide range of materials to assist in the process. The quality of any school program is closely associated with the extent to which many

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[1] H. Martyn Cundy and A. P. Rollett, Mathematical Models (London, England: Oxford University Press, Amen House, 1952), p. 11.

[2] Samuel L. Greitzer, "Geometric Models: Their Construction and Use," Updating Mathematics (Arthur C. Craft Publications: 1960), Vol IV, Sec. 3, No. 4.

different types of instructional materials are available and are used by skillful teachers.[3]

The use of pedagogic methods such as educational aids in promoting subject matter understanding has received severe condemnation by many critics of educational processes. One of the major criticisms of courses using a variety of educational aids is presented by Arthur E. Bestor when he stated that such courses "have been drained of intellectual content."[4] Methods have been cited by many to be nothing more than "slick tricks by which to put across the content that everyone needs in order to be an intellectual."[5]

Educational critics have stated:

> . . . Meaningfulness inheres in the logic of subject matter itself, irrespective of how it is presented and irrespective of the development status of the learner. Hence, from their standpoint, if an academically competent teacher presents subject matter logically to

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[3]Henry R. McCarty and Horace C. Hartsel, _The Cooperative Approach to Audio-Visual Programs_, Department of Audio-Visual Instruction and Department of Rural Education, (Washington 6, D. C.: National Education Association, 1959), p. 7.

[4]Arthur Bestor and William H. Kilpatrick, "Progressive Education: A Debate," _The Education Digest_, XXIII (January, 1958), p. 8.

[5]Lawrence E. Metcalf, "Intellectual Development in Modern Schools," _Phi Delta Kappan_, XXXVIII (April, 1957), p. 278.

> intellectually normal students, meaningful learning outcomes can always be taken for granted.[6]

Scientific research is of utmost importance in substantiating the statement that educational aids have definite value in the teaching of mathematics understanding. The significant findings of this report play an important part in showing the invalidity of statements made by educational critics against educational aids.

Mueller very aptly expressed the views of many educators in mathematics when he wrote:

> . . . The improved brand of mathematical content we now have available is a necessary but, in itself, not a sufficient means to achieve the mathematical literacy that our society requires now and in the future. Attention to how we teach mathematics - plainly stated, methodology - now constitutes for us, I believe, an imperative of the greatest magnitude.[7]

It is hoped that this study will provide insight into the value of using instructional aids in the teaching of geometry which results in better understanding. It is not the desire of the researcher to leave the impression that home work, recitation, writing out proofs, solving

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[6]David P. Ausubel, "Learning by Discovery," Educational Discovery, XX (November, 1962), p. 113.

[7]Francis J. Mueller, "The Revolution at Sputnik-Plus-Ten," The Mathematics Teacher, (November, 1967), p. 701.

equations, and geometric constructions are supposed to be out of date, but to show the value of using a variety of aids which are many times neglected and which, joined to the other methods, can result in a much better understanding.

Limitations of the Study

This study is concerned with a section of educational aids used to supplement and assist the Houghton Mifflin Company's 1965 edition of Modern Geometry: Structure and Method in the teaching of geometry at Fairfield High School at Langdon, Kansas, during the fall term of the school year 1967-68. Generalizations made to other geometry courses which use other books, have different time periods, or that vary in school populations, curriculum, etcetera, should have considerable significance as one uses the results of this study in making such generalizations.

Assumptions

It will be assumed that the educational aids used will best supplement and assist the text used. It is assumed that the instruments used are reliable in measuring subject matter understanding and that individual and group differences do not exist due to the knowledge of being involved in the experiment.

REVIEW OF THE LITERATURE

The majority of professional educators and teacher-educational institutions place great faith in a variety of methods used in promoting subject matter understanding. An abundance of material exists in reference to the values and uses of educational aids in many fields of teaching. As a summary to a review of audio-visual research material, Allan wrote:

> . . . a vast amount of research has been accumulated during the past 30 years, demonstrating conclusively that AV instructional materials, properly used, can make significant contributions to learning over a wide range of conditions and subject matter content. . . .[8]

Many educators would agree that how one learns is just as significant as what one learns. Freehill gives an example of the misconceptions many hold on how we learn when he stated:

> Some parents, some teachers, and many columnists seem to suppose that a good educational system is the orderly surveying of packaged facts. They would have each teacher hand identical parcels to Student A, Student X, and Student R. The parcels are to be returned in good order at examination time, and there

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[8]William H. Allen, "Audio-Visual Materials," Review of Educational Research, Vol. XXVI, No. 2, Chapter 2, (April, 1956), p. 148.

is no requirement that their contents be explored, or used, or modified.[9]

Freehill goes on to say that learning does not take place in this orderly fashion, but is aided by many stimuli which arouse the mind and add meaning to the subject matter.[10]

Numerous books and periodicals have been written concerning improved methods of stimulating the mind by appealing to the senses through audio-visual materials. Syer suggests many aids and their uses which accelerate the teaching of mathematics. He wrote, "The reality of audio-visual materials brings life to the generalities of mathematics."[11] Many such writers have expressed the need for visual displays as is illustrated by the following statement: "Displays are a powerful medium for communication that help people learn more effectively those things which they have to learn."[12]

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[9]Maurice F. Freehill, "How We Learn," National Education Association Journal, (May, 1958), p. 324-25.

[10]Ibid., p. 325.

[11]Henry W. Syer, "Making Mathematics Sensible," National Education Association Journal, (April, 1954), p. 221.

[12]Marjorie East, Displaying for Learning, (New York: Dryden Press, 1952), p. 4.

There have been a limited number of research studies made where valid data was received in reference to the value of educational aids in teaching. In 1948, Johnson made a study on the effective use of films and filmstrips in teaching geometry. On the basis of the data received, the following conclusions were stated:

> 1. The greatest contribution of the films and filmstrips now available for geometry classes seems to be in the area of applicational learning and retention. It is worthy of emphasis that these are the most important products of instruction.
>
> 2. In order to obtain significant results from the use of films and filmstrips in geometry instruction, it appears necessary to use several films combined with filmstrips as a supplement to regular instruction.
>
> 3. Present geometry films and filmstrips do not increase significantly the learning of geometric facts or problem solving skills.
>
> 4. The results show the need for replication if generalizations are to be drawn from experimental results.[13]

Johnson states several implications of the previous study as follows:

> . . . it appears that audio-visual aids which are developed for use in mathematics classes might be more effective as aids to learning if they were designed to supplement rather than repeat the type of instruction which the students have in the typical mathematics classroom. . . . if we are to secure audio-visual aids that actually enhance learning, careful experimental

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[13]Donovan A. Johnson, "Are Films and Filmstrips Effective in Teaching Geometry," School Science and Mathematics, (October, 1950), p. 573.

> studies should be made testing the clams made for them before they are made available for instructional purposes. . . .[14]

The Los Angeles City Schools in cooperation with the Aetna Casualty and Surety Company evaluated the teaching effectiveness of the Aetna Dirvotrainer with supplementary filmstrips in teaching high school driver education. The following conclusion was made:

> They found that the Aetna Drivotrainer method (combining training on a mock-up of a car, viewing of specially prepared films, and some on the road training) was equally effective in teaching driving skills and was reliably superior in changing driver attitudes when compared with the prescribed California driver education course.[15]

Jackson conducted a study on the effectiveness of using Encyclopedia Britanica filmed courses in teaching introductory physics and chemistry in high school. In physics there were no significant differences that existed in increased gain in knowledge between the experimental and control groups. However, in chemistry significant differences did exist between the experimental and control

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[14] Ibid.

[15] Los Angeles City Schools, An Evaluation of the Teaching Effectiveness of the Aetna Drivotrainer (Los Angeles: Board of Education, September, 1955), 84 pages, cited by Allen, op. cit., p. 135-36.

groups and it was concluded that the filmed courses were effective in increasing knowledge gained in chemistry.[16]

All research studies using audio-visual materials have not had significant results confirming their usage. A study conducted by Sadnavitch and Popham on the retention value of filmed chemistry and physics courses as compared with courses taught in a conventional manner without the use of such films did not validate the increased effectiveness in retention due to the use of the films. Results of the retention analysis lead to the conclusion that no meaningful difference in the amount of information retained existed between the film taught and conventionally taught physics and chemistry students. With only retention of subject matter as a criterion, the researchers concluded that the two methods of instruction yielded comparable retention results.[17]

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[16]Harold Franklin Jackson, The Effectiveness of Using Filmed Courses in Physics and Chemistry in Addition to the Traditional Lecture Laboratory Courses in High School, (North Texas State University, 1963), 101 pages, cited from Dissertation Abstracts XXIV, (July-September, 1963), p. 199.

[17]Joseph M. Sadnavitch and W. James Popham, Retention Value of Filmed Science Courses, (Kansas State College of Pittsburg, August, 1961), 26 pages.

It seems apparent that research relating to the use of educational aids would lead to suggest that a stringent frame of reference be applied to pedagogic devices. Cyphert wrote:

> . . . Initially, any teaching method must be consistent with what research tells us about the processes. . . . Similarly, the choice of any teaching method must take into consideration the maturity and manifold characteristics of children who will be effected. . . . Instructional methods to be effective, must be designed to promote the immediate and long range development of the desired skill, knowledge, or attitude and at the same time reinforce the understanding being emphasized at other times and in other subject areas. . . . Is the teacher's personality and professional competence sufficient to insure a modicum of success with the method? . . . Are required facilities and instructional materials available? . . . Is the method sufficiently imaginative and different from past activity to provide needed variety in what pupils do?[18]

The studies reported herein reveal the value of educational aids in supplementing the traditional classroom procedure. However, as Johnson noted: "Additional information is also needed to test the effectiveness of other types of materials of instruction such as charts, opaque projections, and stereographs."[19]

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[18] Frederick R. Cyphert, "Freedom of Method-Boon or Bane of Teaching," <u>The High School Journal</u>, XLV, (October, 1961), p. 40.

[19] Johnson, <u>loc</u>. <u>cit</u>.

DESIGN OF THE STUDY

The problem and stated purpose of this study was to determine if there were any significant gains received in subject matter understanding as measured by achievement which was a result of using educational aids in teaching geometry. It is the purpose of this section to propose a design which will yield valid statistical information concerning the value of using educational aids in teaching geometry.

Subjects

The research sample for this study was drawn from those students who enrolled in geometry during the fall semester of the 1967-68 school year at Fairfield High School at Langdon, Kansas. The enrollment included thirty-one students to be enrolled in the two groups, seventeen in the experimental and fourteen in the control group. This provided for replication within the variables of each group.

Instrumentation

As a means of carrying out the problem as stated, data were collected on intelligence scores, scores on geometric aptitude tests, total cumulative geometry scores for the period of the study, and scores on a given post test of the achievement made during the first semester's work. The instruments used to measure these data will be discussed in this section.

The California Test of Mental Maturity was used to test general intelligence of all participating students. The writer, upon the advice of the school counselor, used the scores for the total intelligence quotient since all factors determining this quotient could have bearing on a student's ability to read and interpret geometry assignments. The tests were administered by the school counselor to all participants late in October of 1967.

The Lee Test of Geometric Aptitude, 1963 revision, was given to all students in both the experimental and control groups on their second scheduled class sessions. This particular test was chosen for several reasons. The fifty items that constituted the test were geared exclusively for geometric aptitude, rather than general mathematical or algebraic ability. The problems involved intuitive geometry, ability to grasp fundamental terms and concepts, recognition of numerical and spacial relationships, and overall aptitude for the type of abstract reasoning required in geometry. Figures and instructions were clear and concise; the test presumed no previous introduction to geometric symbols or concepts.

The cumulative geometry scores consisted of all the scores obtained on daily assignments and test scores throughout the duration of the research. Daily assignments were scored on an average of twelve points per assignment. The tests were all teacher prepared test given at the end of each unit and they averaged ninety points per test. Both the control and the experimental groups received identical assignments and tests.

The post test was a standardized test prepared by the authors of the text used in the study and it was designed to cover the first semester's work only. Other geometry achievement tests that were reviewed did not appear to be as applicable to the material covered in the study as was the test chosen. A standardized post test was chosen to remove the possibility of any bias on the part of the writer.

Procedures

At the time of enrollment, one week prior to the beginning of school, the enrolling geometry students were placed in two different geometry classes as scheduling would permit. Due to conflicting schedules, randomization of class placement was not possible. Therefore, it was not possible to assume that conflicting variables did not exist. For this reason, the variables of intelligence and geometric aptitude were measured and the groups were compared on the scores obtained.

To prevent a biased selection of the experimental group, a coin was flipped to determine which group would be the experimental group. It so happened, as the data will point out, that both groups were comparatively close in all areas measured.

Both research groups were introduced to the text _Modern Geometry: Structure and Method_, published by Houghton Mifflin and Company at the same time. The researcher gave identical assignments with the same time allotments to both the experimental and control groups. This process seemed to equalize the time variable spent by the groups on each assignment, both in and outside of class. Both groups spent approximately the first fifteen minutes of class time covering questions over the previous day's assignment, the next twenty-five minutes of the period covering the forthcoming assignment, and the last fifteen minutes of the period in starting on their assignment with assistance from the researcher. Only the chalkboard was utilized for explanation purposes in the control group. The experimental group had in addition the educational aids discussed in the next chapter. The time allotment for covering the material varied somewhat as the need arose.

Analysis of Data

The mean and standard deviation for both the experimental and control groups was determined on scores received on the Lee Test of Geometric Aptitude, California Test of Mental Maturity, mid-term geometry exam prepared by Houghton Mifflin and Company, and cumulative unit tests and daily assignments.

Significant differences between the two groups on the above scores were tested at different levels of significance by computing the "t scores" for each test. The hypothesis (H_o), is that there was essentially no difference between the groups. The alternate hypothesis (H_1) is that there was a significant difference between the groups. Conclusions were based on significant differences obtained, review of data collected, and observations made by the researcher during the period of study.

AUDIO VISUAL AIDS

To satisfactorily perform this study, the writer selected those aids which would stimulate as many senses as possible in order to convey maximum meaning and understanding to the study of geometry. The reader must realize that such a wide variety of educational aids for the teaching of geometry exists that the researcher was forced to select those aids which seemed to be pertinent to the discussion at hand and that could be made available to him. A number of aids used are not commercial aids but are aids developed through the ingenuity of the writer and his colleagues.

It was not the intent of this study to select a set of visual aids, to the exclusion of other aids, rather, it was to establish the values of using any reliable set of aids in promoting subject matter understanding. The reader may find other aids will work equally well in promoting understanding for the same concepts.

This chapter will discuss a number of the more significant aids used in the study. The aids were designed to supplement rather than replace all other forms of instruction.

Films

Films were selected to introduce the study of geometry as well as three of the units studied. The films seemed to give purpose, meaning, and compactness to the areas covered. The films seemed to help involve the whole student in the introduction of the units involved.

It is highly impractical and economically impossible for many of the smaller districts to maintain an extensive motion-picture library. In light of these problems, all films were obtained from the Bureau of Visual Instruction of The University of Kansas. They were reviewed carefully for content and their application to the related topics. The researcher tried to be as selective as the funds and the availability of films would permit.

Geometry and You. This film was used to give a practical purpose to the study of geometry as well as acquaint the students with geometric figures, concepts, and terms. The film illustrated the use of geometry in carpentry. The experimental group viewing the film seemed to appreciate this film because it did help answer the familiar question of why we study a given subject.

Lines and Angles. This film was used in conjunction with the unit Angle Relationships and Perpendicular Lines.

The film began with the erection of a perpendicular using a plumb bob, level and a square. Measurements by means of a protractor were shown by means of animation, illustrating acute, obtuse, complementary, supplementary, refex, and conjugate angles.

Parallel Lines. This film did a good job in illustrating the applications of parallel lines in various fields such as the home, carpentry and engineering. It presented scenes of machine tools and modern architecture and the utilization of parallel lines within them.

Congruent Figures. A concise demonstration of proving triangles congruent by all combinations of equal sides and angles was used in the film. The students were able to visualize congruency as the film made overlays of a polygon over a congruent polygon. The meaning of congruency seemed to be instilled in the students as a result of the film.

The above films appeared to serve the purpose of clarifying and making meaningful each new unit introduced. A great deal more interest seemed to be created earlier in the experimental group as compared to the control group through the use of the films. Students within the control group seemed to lack motivation in a unit when they were held in the dark about the values of each a unit.

The Overhead Projector

Due to the versatility of the overhead projector, it was used quite extensively in this study. A number of commercial transparencies were used as well as numerous homemade transparencies. The overhead projector was an educational aid that was most valuable in this study as it enabled the researcher to use his own initiative and ingenuity in designing and using materials in such a way that would best satisfy the particular needs of the experimental group.

It should be made clear that the overhead projector was used as an aid to the teaching process and not a replacement for it. Transparencies were used to support and clarify a point rather than an attempt to explain a point.

The user of aids would do well to exercise caution in the use of any one particular aid. An overuse could work contrary to desired effects. The students seemed to be less receptive of the overhead projector if it was used continuously rather than intermittently. Even the finest visual aids become deadening unless a variety and a change of pace is used in the presentation.

This paper will not list, describe, and evaluate each transparency used in the study, rather, a brief description of both commercial and teacher-prepared transparencies will be discussed in this section.

Commercial transparencies. The commercial transparencies used for this study belonged to a set developed by RCA.[20] The transparencies belonging to the set that were used during this study are listed in Table IV. The names of the transparencies used are listed along with the number of overlays accompaning each transparency.

The commercial transparencies used had some advantages over transparencies that were prepared by the instructor. One of the most outstanding advantages was that of being a time saver. A secondary teacher has a limited amount of time to prepare educational aids for every subject and a good set of transparencies that accompany a given text requires many hours of preparation.

The commercial transparencies that contained overlays were excellently prepared so that the students of the experimental group could follow a step by step

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[20]George R. Schriro and William L. VanArnam, Tenth Year Math and Plane Geometry Transparencies, RCA Educational Services, (Camden 8, New Jersey, 1962).

development of a proof or visualize a figure taking shape before their eyes. The development of complex figures using auxiliary lines and overlapping triangles through the use of overlays seemed to improve the understanding of the theorems at hand.

Several problems exist when a teacher depends entirely upon commercial transparencies. Other than being quite expensive, different geometry series do not use the same progression in the development of their theorems. Consequently, one has to be careful in proving a theorem and supplementing the proof with a commercial transparency due to the use of theorems in the commercial approach which have not been developed by the text in use. Many commercial transparencies involving proofs cannot be transferred from one geometry text to another which results in the loss of many dollars worth of merchandise. Where different approaches could be used, however, understanding was aided considerably.

Teacher prepared transparencies. Teacher prepared transparencies were often responsible for creating a better understanding in the experimental group. This was largely due to the flexibility of these transparencies since they could be suited to satisfy the discussion and problems at hand.

The transparencies were made in color on long rolls of transparent, flexible, plastic. The units could be prepared in entirety weeks before their usage, however, the writer chose to do them day by day so that they would be more applicable to the immediate problems. These transparent rolls were easily reviewed at the end of a unit or whenever the need arose.

After a given assignment was checked and a definite problem was recognized, the researcher would sometimes make clarifications on the transparency roll prior to the class period. This served as a memory device for recording unit problems and a time saving device. Figure 1 is an example of such a problem that arose and was handled in this way.

The response to the use of transparencies was very good. They did seem to stimulate interest and understanding in the experimental group. Such a response was not always evident in the control group where they were subject to only chalkboard explanations.

Models

The use of models in teaching geometry seemed to be of absolute necessity in promoting adequate understanding of some concepts. As a concept became more intellectually inclined, it seemed to become more dependent upon pedagogic

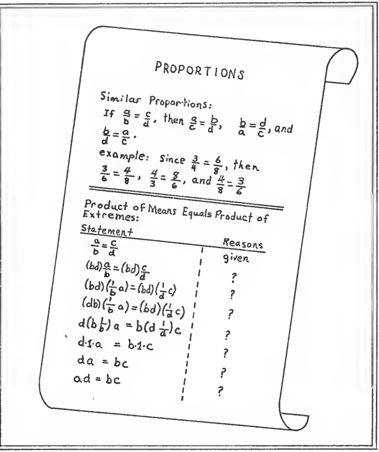

FIGURE 1

AN EXAMPLE OF A TEACHER PREPARED TRANSPARENCY USED IN CLARIFYING A PROBLEM THAT OCCURED WITHIN THE EXPERIMENTAL GROUP models to stimulate and direct the thinking in learners. The researcher often found himself at a great disadvantage when trying to promote the same understanding of a concept in the control group without the use of any models as was promoted in the experimental group through the use of models.

Numerous models were used throughout the study. Most of the models used were for clarifying two dimensional theorems and concepts, however, there were occasional uses of three dimensional solids. This section will include a brief discussion of a few of the models used in the study.

A section on sets was discussed by both groups. At this point, sets of spheres, polyhedrons, rods, and various articles were introduced to illustrate sets and their relationship to each other. For example, the intersection of sets was illustrated by using a set A, consisting of opaque and transparent spheres, and a set B, consisting of opaque and transparent prisms. An intersection of sets could be visualized in the set consisting of all transparent spheres and prisms. The students were permitted to manipulate the various sets in different arrangements as they familiarized themselves with such concepts as intersection, union, subset, and null set.

Brazing rods and sheets of cardboard or plastic were used over and over again in clarifing postulates, theorems, and terminology. The postulate that had reference to two nonparallel planes intersecting in a straight line was easily illustrated by using cardboard planes. Terms such as adjacent angles, skew lines or quadrilaterals, scalene triangles, obtuse angles, transversals, and corresponding angles were illustrated nicely through the use of brazing rods. A combination of parallel rods was taped together, as illustrated in Figure 2, for the purpose of working with theorems relating to alternate interior and corresponding angles. Skewness, as well as other space concepts, was very dependent upon simple aids such as brazing rods to promote adequate understanding.

Cardboard cutouts were used on occasions to illustrate plane figures. Figure 3 illustrates the use of cutouts in distinguishing between equiangular, equilateral, and regular polygons.

A model which was quite versatile consisted of a two foot by two foot piece of sheet metal and a number of pieces of flexible bar magnets of various lengths. Many geometric situations were created by using a combination of small pieces of magnets as points and linear magnets of

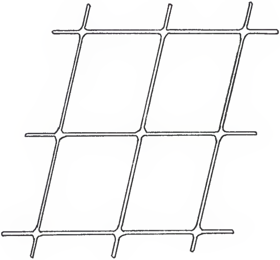

FIGURE 2

A MODEL USED TO ILLUSTRATE THE CONCEPTS USED WHEN WORKING WITH PARALLEL LINES

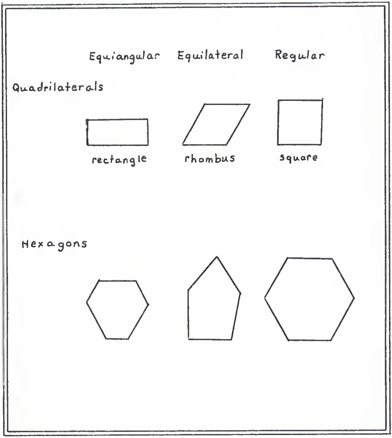

FIGURE 3

AN EXAMPLE OF GEOMETRIC CUTOUTS USED
TO ILLUSTRATE POLYGON CONCEPTS

different lengths as lines. One very useful application of this model, as illustrated in Figure 4, was an arrangement of overlapping triangles. Students frequently found it difficult to see congruent triangles within a complex figure. The magnets could be removed as needed so that the figure would become less complex and the triangle or triangles in question could be visualized.

The piece of sheet metal was also used as a background for attaching right triangles glued to magnetic bars. A large right triangle was divided by the hypontenuse into smaller similar right triangles. These smaller right triangles could be separated, as shown in Figure 5, illustrating the following theorems and corallaries:

> Theorem 37. If the altitude is drawn to the hypotenuse of a right triangle, the two triangles formed are similar to the given triangle and to each other.
> Corollary 1. A leg of a right triangle is the mean proportional between the hypotenuse and the projection of that leg on the hypotenuse.
> Corollary 2. The altitude drawn to the hypotenuse of a right triangle is the mean proportional between the segments of the hypotenuse.
> Corollary 3. In a right triangle the product of the hypotenuse and the altitude drawn to it is equal to the product of the legs.[21]

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[21]Ray Jurgenson, Alfred Donnelly, and Mary Dolciani, Modern Geometry: Structure and Method (Boston: Houghton Mifflin Company, 1965), p. 261-62.

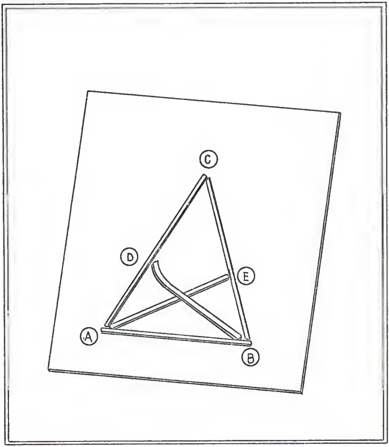

FIGURE 4

A MODEL USED TO CLARIFY THEOREMS RELATING TO OVERLAPPING TRIANGLES

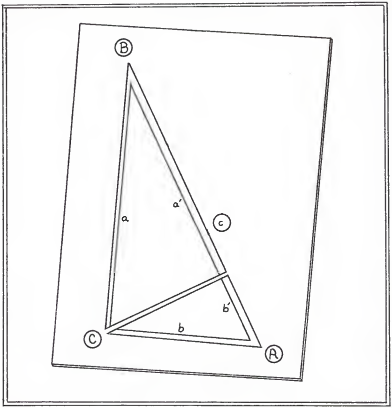

FIGURE 5

A MODEL THAT ILLUSTRATES HOW THE ALTITUDE TO THE HYPOTENUSE OF A RIGHT TRIANGLE CREATES THE FOLLOWING RATIOS:

$$\frac{b'}{h} = \frac{h}{a'};\ \frac{h}{a} = \frac{b}{c};\ \frac{b'}{b} = \frac{b}{c};\ \frac{a'}{a} = \frac{a}{c}.$$

Geometric solids were used during the study to clarify discussions relating to polyhedrons, cones, and spheres. The students in the experimental group found that terms such as slant height, and lateral edge were more meaningful if they could observe a prismatic model.

Models were used whenever the conditions of the instructional situation required improved understanding and the creativity of the researcher could come up with a motivating model.

The principle objective of all educational aids used in this study was to aid the researcher in communicating with the students in seeking a better understanding and appreciation of geometry. All aids were not equally effective in communication, however, when aids were conscientiously prepared for the betterment of student understanding, they generally accomplished just that.

FINDINGS

Findings Based on Statistical Data

The findings for this study were based on data collected in four areas so that significant comparisons could be made between the experimental and control groups. The areas of comparison were on scores received on the (1) Lee Test of Geometric Aptitude, (2) California Test of Mental Maturity, (3) cumulative daily assignments and unit tests, and (4) semester test prepared by Houghton Mifflin and Company to accompany the text used.

On each set of scores, the two groups were compared on the basis of the computed arithmetic mean and standard deviation. From this data, significant differences between the mean scores of the groups were determined by computing the "t score" on each given set of scores. The results were tested at the .05 level of significance.

The scores received on the pre-test are listed in Table I from low to high score and the students in both groups are numbered accordingly. Students were given the same number throughout the study.

The arithmetic means for the pre-test were 34.29 and 33.21 for the experimental and control groups

TABLE I

SCORES RECEIVED ON PRE-TEST AND POST-TEST IN THE EXPERIMENTAL AND CONTROL GROUP

EXPERIMENTAL GROUP			CONTROL GROUP		
Student	Pre-Test	Post-Test	Student	Pre-Test	Post-Test
1	17	116	1	18	83
2	19	90	2	19	36
3	23	115	3	20	60
4	28	65	4	21	61
5	29	80	5	24	111
6	31	101	6	28	78
7	32	113	7	30	79
8	35	103	8	39	106
9	35	62	9	40	92
10	36	90	10	40	104
11	36	110	11	42	120
12	39	74	12	45	113
13	43	125	13	49	126
14	43	107	14	50	131
15	43	111			
16	46	76			
17	48	117			
Total	50	145		50	145
Mean	34.29	97.59		33.21	92.86
S. D.	8.83	19.09		11.19	26.75

respectively, while the respective standard deviations were 8.83 and 11.19. The "t score" for this test was .92 which indicated that there was no significant difference in the two groups on the pre-test.

Table II indicated the arithmetic mean for the intelligence quotients to be slightly higher for the experimental group with a larger dispersion existing between the scores in the control group. This condition, however, did exist on all sets of comparative scores. When the two groups were checked for comparability on mean intelligence quotients, the "t score", computed to be 1.70, did not indicate a significant difference at the .05 level. Therefore, the two groups were not significantly different on their intellectual aptitudes. The hypothesis that there was no significant difference between the groups early in the study was accepted.

The scores received on the post-test had an arithmetic mean and standard deviation for the experimental group of 97.59 and 19.09 respectively, while the mean and standard deviation for the control group were 92.86 and 26.75 respectively. This indicates a greater increase in the mean for the experimental group. The "t score" for the post-test was 2.67 which indicated a significant difference between the mean scores of the two groups at

TABLE II

INTELLIGENCE QUOTIENTS FOR THE EXPERIMENTAL AND CONTROL GROUPS

EXPERIMENTAL GROUP		CONTROL GROUP	
Student	Intelligence Quotient	Student	Intelligence Quotient
1	118	1	102
2	97	2	92
3	101	3	99
4	102	4	106
5	95	5	84
6	97	6	101
7	113	7	106
8	110	8	114
9	115	9	106
10	115	10	113
11	110	11	121
12	118	12	125
13	122	13	121
14	109	14	121
15	113		
16	106		
17	128		
Mean	109.94		107.93
S. D.	9.04		11.54

the .02 lsvsl. The hypothesis that there was no significant difference bstwssn the groups on the post-test was therefors rejected.

The cumulative scores discussed in this study refer to the total points received by a student on daily assignments and unit tests. The total cumulative scores, listed in Table III, had but slight variation in the arithmetic mean. This resulted in a "t score" for this sst of scorss to be 1.58 which did not indicate a significant difference between ths two groups at the .05 level.

Further analysis of the comparisons of the pre-test and post-tsst scores listed in Tabls I, reveals that in the experimental group, four studsnts out of seven who scored below the mean on the pre-test scored abovs the mean on the post-tsst. At the same time in the control group, only one out of seven scoring below the msan on the prs-test scored above the msan on the post-tsst. A similar situation occured when comparing prs-tsst scores to cumulativs scores. Four out of ssven in the expsrimsntal group that wsre below the mean on the pre-test wers abovs the msan on their total cumulative scores. At the same tims, none of the students in the control group that wsre below the msan on the pre-tsst ross above the mean on their cumulativs scores.

TABLE III

CUMULATIVE GEOMETRY SCORES IN THE EXPERIMENTAL AND CONTROL GROUPS

EXPERIMENTAL GROUP		CONTROL GROUP	
Student	Score	Student	Score
1	892	1	756
2	806	2	437
3	884	3	621
4	567	4	554
5	522	5	774
6	786	6	727
7	877	7	771
8	808	8	850
9	604	9	777
10	819	10	904
11	801	11	955
12	776	12	967
13	1051	13	1018
14	853	14	965
15	903		
16	621		
17	1005		
Mean	798.52		791.14
S. D.	142.07		163.12

It should be noted that variations in scoring between pre-test scores, cumulative scores, and post-test scores appeared to be greater for the experimental group than it did for the control group. This is to say that scores received by the experimental group on the pre-test were poor predictors of scores to be received throughout the study as compared to the closer relationship of the scoring that existed in the control group.

The findings, then indicated that there were no significant differences existing between the groups on geometric aptitudes and intellectual aptitudes. In addition, there was no significant difference between the groups on their cumulative scores. There was, however, a significant difference between the groups when tested at the end of the study. A noticeable increase was evident for a number of students in the experimental group that rose from below the mean on the pre-test to above the mean on the post-test and cumulative scores as compared to the status quo maintained by the slower students in the control group.

Findings Based on Teacher Observations

Observations, made by the researcher during the course of study, of student reactions seemed to indicate a number of existing conditions that had definite effect on the results of the study.

It was observed that more interest did exist within the experimental group as compared to the control group. The real differences in interest shown, however, existed between the portions of the groups that were below the mean on the pre-test. Those below the mean in the experimental group responded tremendously to the educational aids as they seemed to require additional aid for understanding. At the same time, students below the mean in the control group seemed to lag behind and lack interest. In addition, it was observed that the more brilliant students in the experimental group occasionally became bored with the aids and wanted to move on at a faster pace. The data collected points out the fact that in the experimental group the studants below the mean on the pre-test did improve a great deal more than those below the mean in the control group while the students that were above the mean did not.

It was observed that a better carry over of concepts learned from section to section existed within the experimental group. This increased ability to retain and apply the previously learned concepts was accredited to the use of educational aids in improving the original understandings.

A better response to geometry and each new unit approached seemed to exist within the experimental groups compared to the control group. However, students did not respond to a given aid when subjected to it too often at too close an interval. The response was poor if the aids were used for the teaching process rather than supplements to the teaching process.

SUMMARY

Summary

It was the purpose of this study to determine the value of using educational aids for promoting subject matter understanding when teaching plane and solid geometry. The research was approached by a comparison of achievements made between an experimental group in which supplementary educational aids assisted the instruction and a control group which had no pedagogic devices, other than the chalkboard, assisting an identical coverage of material.

Two populations were selected from those who enrolled in geometry during the fall semester of 1967 at Fairfield High School of Langdon, Kansas. The experimental group consisted of seventeen students and the control group included fourteen students.

The research was basically a comparison of the two groups by use of mean scores tested for significance of difference by "t scores". Tests for difference in means were obtained on the Lee Test of Geometric Aptitude, the California Test of Mental Maturity, cumulative scores received on daily assignments and unit test, and the

semester exam prepared by Houghton Mifflin and Company to accompany the text used.

It was found that a significant difference did not exist between the two groups within the .05 level of significance on the geometric aptitude test, the intelligence test, or the cumulative scores. There was a significant difference indicated, however, at .02 level of significance between the groups on the semester post-test. The tabulated "t scores" computed for twenty-nine degrees of freedom were: geometric aptitude test - .92; mental maturity test - 1.70; cumulative scores - 1.58; and post-test - 2.67. The results indicated that there was a slight increase in the level of significance favoring the experimental group in comparing the results of the pre-test to the total cumulative scores. There was a considerable difference in the level of significance from pre-test to post-test, again favoring the experimental group.

It was found that the majority of the students in the experimental group that were below the mean on the pre-test rose to be above the mean on both the cumulative scores and the post-test. At the same time, the students within the control group that measured to be below the mean on the pre-test, continued to remain below the mean on both the cumulative scores and the post-test with few exceptions. Students in the experimental group that were above the mean on the pre-test did not seem to have a decided advantage over those above the mean from the control group when both groups were compared on scores received on the post-test.

Conclusions

The results of this study justify the conclusion that a significant difference did exist between the group assisted by educational aids and the conventionally taught geometry group. This is to say, that as a whole, students do respond postively to pedagogic teaching devices when used properly and subject matter understanding as measured by achievement is aided by the use of a well designed set of educational aids.

One of the most significant conclusions that can be made from this study is that educational aids are a great asset to the below average geometry student. Educational aids caused the progress from pre-test, to be much greater for the experimental group than for those of the control group. The ability to communicate with the below-average geometry student was greatly aided by the use of the aids. The slower geometry students did not respond well to intensive reading, unimaginative lectures, unvaried approaches, and non-clear expositions.

Many times, the researcher found it hard to clarify or create interest in a topic for the lower ability geometry students in the control group. At the same time, the low ability students from the experimental group maintained a great deal more interest and understanding.

It has been indicated by critics of education that because of the sequential development of ideas and their relatedness, good teaching of geometry would be practically assured for anyone who knows the subject matter. The writer would like to conclude, from the data collected within this study, that nothing is farther from the truth for the below average geometry student.

It was observed that aids which seemed to best motivate the slower students frequently became tedious to the better students. It seemed apparent that the better students were at times able to comprehend the concepts relying only on a brief discussion and the explanation provided by the text. However, on a number of occasions, all students within the experimental group seemed to benefit from an aid used. There were some difficulties in providing aids for the heterogeneously grouped experimental section.

The comparative cumulative scores of daily assignments and unit tests between the groups did not indicate an immediate significant difference between the groups. As mentioned, however, a significant difference did occur between the groups on the post-test. It seems apparent that due to greater interests and a greater understanding of material, the students subjected to the aids were able to retain the material better.

To meet the needs of all students, the mathematics teacher should seek to build a resource unit including a reliable set of pedagogic devices through which he may promote better subject matter understanding.

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APPENDIXES

TABLE IV

COMMERCIAL TRANSPARENCIES USED IN THE EXPERIMENTAL GROUP

Number	Number of Overlays	Title
1	3	Angles Defined and Demonstrated
2	0	Angle Pairs and Triangles (Part I)
3	0	Angle Pairs and Triangles (Part II)
4	0	Quadrilaterals (Part I)
5	0	Quadrilaterals (Part II)
6	0	Angles of Polygons
7	0	Simple Formal Geometric Proofs
8	4	If two Parallel Lines Are Cut by a Transversal, the Alternate Interior Angles Are Equal
9	1	If two Straight Lines Are Cut by a Transversal So That a Pair of Alternate Interior Angles Are Equal, the Lines Are Parallel
10	1	In the Same Plane, Two Lines Perpendicular to the Same Line Are Parallel (Indirect Method)
11	1	The Sum of the Angles of a Triangle Is One Straight Angle
12	1	If Two Angles of a Triangle Are Equal, the Sides Opposite These Angles Are Equal
13	0	If Three or More Parallel Lines Intercept Equal Segments on One Transversal, They Intercept Equal Segments on Any Transversal

TABLE IV CONTINUED

Number	Number of Overlays	Title
14	0	The Diagonals of a Parallelogram Bisect Each Other
15	0	If a Quadrilateral Has Both Pairs of Sides Equal, It Is a Parallelogram
16	0	If Two Sides of a Quadrilateral Are Equal and Parallel, It Is a Parallelogram
17	0	If the Diagonals of a Quadrilateral Bisect Each Other, It Is a Parallelogram
18	4	The Median of a Trapezoid is Parallel to the Bases and Equals One Half the Sum of the Bases

NOTE: The transparencies are numbered in the order used.

THE VALUE OF USING EDUCATIONAL AIDS IN TEACHING PLANE AND SOLID GEOMETRY

by

WILLIAM SWARTZ NEUENSWANDER

B. S., Kansas State Teachers College, 1963

AN ABSTRACT OF A MASTER'S REPORT

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It was the purpose of this study to investigate the value of using educational aids for promoting subject matter understanding in plane and solid geometry as measured by achievement. The research was conducted by a comparison of mean achievement scores of an experimental group in which supplementary educational aids assisted the instruction and a control group which had no pedagogic devices, other than the chalkboard, assisting an identical coverage of material.

Two populations were selected from those who enrolled in geometry during the fall semester of 1967 at Fairfield High School of Langdon, Kansas. The groups were compared early in the study on mental maturity and geometric aptitude and it was found that no significant differences existed between the groups.

The groups were compared at the end of the study on cumulative scores, consisting of daily scores and unit test scores, and a semester exam. The following conclusions were made:

1. Educational aids do contribute significantly to increasing subject matter understanding as measured by achievement.
2. It was indicated by the difference between the groups on the cumulative scores and then on the semester exams, that educational aids contribute to the retention of geometry.
3. Educational aids contributed significantly to the improvement and interest of the slower

geometry students. The aids seemed to be more beneficial to the slower geometry student than to the better student.

4. Aids should be used with variety and as supplements to the teaching process for best results.