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An investigation of high school pupils' opinions on methods of teaching mathematics

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AN INVESTIGATION OF HIGH SCHOOL PUPILS' OPINIONS ON METHODS OF TEACHING MATHEMATICS

Submitted by
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(B.S. in Ed., Boston University School of Education, 1947)

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CHAPTER I

THE PROBLEM AND PREVIOUS RESEARCH

THE PROBLEM

Statement of the Problem. The primary purpose of this study is to determine the extent to which high school pupils are aware of the methods and techniques by which they are being taught mathematics. Do high school pupils observe differences in ways of teaching, or is all teaching considered by them to be a machine-like process with little variation, and that of no consequence? This is the first question which the study attempts to answer, and it gives rise to two others, each of which the writer feels must be investigated if the problem is to be treated adequately:

The questions are:

1. Which techniques and procedures of teaching mathematics do high school pupils prefer?
2. Which techniques and procedures do pupils regard as most valuable, and which least valuable?

Although the questions appear to be nearly alike, it will be seen that the second gives a pupil the chance to indicate that a certain technique has been valuable in spite of the fact that another was liked far better.

Importance of the Study. Methods in techniques of instruction are a very important aspect of good teaching. In the past, the decision as to which methods and techniques of teaching

secondary mathematics were the best has been almost entirely in the hands of educators. The response to this statement would generally be, "But aren't they the ones who should decide how mathematics is to be taught?" To answer "yes" is to disregard completely those individuals most directly concerned--the pupils. The pupils are the ones who are meant to reap the fruits of instruction, so why not give them an opportunity to at least express an opinion on the question? It is to obtain such an opinion and to relate its implications to the overall picture of teaching methods that work of this study is directed. It is hoped that the results of the study will be useful not only to those educators who set the policies, but to classroom teachers of mathematics in improving the quality and efficiency of their instruction, and to future researchers using the method of this study, the student interview.

PREVIOUS RESEARCH

Although pupil attitude and opinion surveys have been conducted on a large scale in recent years, little study has been done that has been directly concerned with mathematics, and particularly with methods of teaching mathematics. This type of research has presented a broad front in nearly all major fields of secondary instruction except mathematics.

In reviewing previous research the author used the Boston Public Library and the libraries of Boston and Harvard Universities. The particular sources of information consulted

were:

1. Educational Index
2. Reader's Guide to Periodical Literature
3. Review of Educational Research
4. Cumulative Index (1928--)
5. The Mathematics Teacher (Periodical)
6. School Science and Mathematics (Periodical)
7. The library catalogues of the two libraries named.

No studies using the interview technique of investigation were found. The studies reviewed were carried out by means of pupil questionnaire.

The earliest study concerning mathematics was that of Gingery,[1] in which a questionnaire was used to tell which subjects were preferred by pupils. The questionnaire was given to 302 second semester high school freshmen, all of whom were required to take English and mathematics, the other subjects being electives. 101 pupils placed mathematics first, while 104 preferred English. The pupils were asked to tell why they liked best the subject placed first. In the words of the investigator: "The answers to this question were not especially illuminating. Of the 101 who preferred mathematics, 20 indicated that it was because they had good teachers....The conclusion seems to be, without question, that mathematics is neither more nor less disliked than other required subjects of the

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[1] Gingery, W. G., "Do High School Pupils Dislike Mathematics?" School Science and Mathematics 21:674-675, October, 1921.

first year high school course."[1] A similar study was carried out by Butler[2] to determine by means of an eight-question, "yes or no" questionnaire the extent to which high school pupils enjoyed work in mathematics. The tabulations showed almost no percentage difference (2%) between the "yes" replies of boys and girls. The boys were two percent above the girls. Butler also concluded that so far as the questionnaire covered the field of mathematical enjoyment, and so far as the group was representative of the school, about forty-eight percent of the possibilities for mathematical appreciation and enjoyment are realized, at least in some measure.

In an observation study of 48 eighth grade pupils at the University of Chicago High School, McWilliams[3] concluded that too many simple questions were asked, and that too little emphasis was put on class discussion. This study was too short for making definite conclusions.

Bolton[4] developed two comparable attitude scales to be used for investigation of related common attitudes of interest in and appreciation of the value of mathematics. The study was carried out with college students, and the author found that the instrument was valid in terms of the criteria used,

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[1] Gingery, W. G., Op. Cit., p. 675.
[2] Butler, Charles H., "How Much Do Pupils Enjoy Mathematics?" Mathematics Teacher 23:309 May, 1930.
[3] McWilliams, Lulu E., "A Study of Pupil Reactions" Mathematics Teacher 22:292 May, 1929.
[4] Bolton, Euri Belle, "The Measurement of Attitudes Toward Mathematics" Psychological Monographs Vol. 50 No. 225, 1938, p. 155-182

and that women do not as a group dislike mathematics.[1]

Only a few studies outside the field of mathematics will be discussed, and those mentioned will be studies of pupil attitudes toward teachers and teaching.

Doll,[2] in an interesting questionnaire study, reached five conclusions concerning high school pupils' attitudes: (1) In general, pupils prefer democratic to autocratic procedures. (2) Youth like to have assignments that are definite and meaningful, but not dictatorial. (3) Pupils find more flaws in traditional teaching methods than teachers appear to recognize. (4) Learners' attitudes toward teaching and teaching methods require more thorough study. (5) Instruments such as the "expressionnaire" used in the investigation need refinement before they can be used with assurance in measuring pupils' attitudes.

Conclusions (1) and (3) are subjects which this writer treats at greater length in this thesis.

One investigation, carried out by McSweeney[3] on sixth grade pupils, was for the purpose of determining the appeal of the Individual, Group or Class method of teaching in different activities. The results obtained with the questionnaire showed that no single method is best for all activities and

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[1] Bolton, Euri Belle, Op. Cit., p. 176
[2] Doll, Ronald C., "High School Pupils" Attitudes Toward Teaching Procedures" School Review 55:226-227 April, 1947.
[3] McSweeney, M. J., "An Evaluation of the Relative Appeal of Three Teaching Procedures on Five Assignment Activities" Unpublished Ed. M. Thesis, Boston University, 1945.

that the method must be suited to the type of activity.

Studies such as these have not been confined to the public school level of education. Copper[1] in a short study at a state teacher's college in Michigan, asked students "What is Good Teaching" and listed the answers in order of frequency as requisites of good teaching. Arousing interest in the learner was placed first. Also at the same level Perrigo[2] learned that college students prefer combined lecture, discussion and reports in social studies, and that half of the group investigated preferred daily assignments. Wykoff[3] asked college students to write a paper giving constructive and destructive criticisms of his course and the manner in which it was taught. The papers proved to be illuminating as well as entertaining.

The studies cited indicate a desire on the part of educators to learn more about the student as a human being that is alive to the methods and procedures to which he is submitted while in the classroom. This study purposes to carry such investigation to the pupil personally, to determine firsthand what the pupil thinks concerning methods in teaching mathematics.

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[1] Copper, Francis Roy, "What is Good Teaching?" Education 56:567 May, 1936.
[2] Perrigo, Lynn I., "Evaluation of Teaching Devices by Student Questionnaire." Education 58: 236 December, 1937.
[3] Wykoff, G. S., "Some Examples of Student Criticisms of Teaching" School and Society 30: 512-513 October 12, 1929.

CHAPTER II

METHOD OF INVESTIGATION

Reasons for choosing the interview technique. Several techniques of investigation would have obtained information upon this particular subject, but none would have been so adaptable as the interview to the purposes which the writer had in mind.

Since the problem of the study was to learn what opinions high school pupils have toward methods of teaching mathematics, it was necessary to choose a technique of gathering information in which the population being surveyed could give free expression without being bound by the limitations of direct questions. The author felt that this condition could be filled adequately only by the use of the student interview.

In 1933 Hartmann made mention of the following advantages of the interview, quoted from his article in the Journal of Applied Psychology. "Misconceptions as to meaning can be cleared up; supplementary questions will elicit more definite answers; the person interviewed will supply the material more readily because the mechanical effort of writing demands too much of his time; and last but not least, from the standpoint of adequate sampling, more questions are answered, and the

separate replies tend to be more detailed."[1] These advantages, particularly the first and last, summarize the author's reasons for using the student interview.

Procedure. In preparation for the investigation, a careful study was made of the interview techniques of Bingham and Moore[2] and Garrett.[3] In order that more pupils could be interviewed, with less distraction for the classrooms, the decision was made to take pupils for interviews in pairs.

The first fifteen interviews were experimental, and were used to improve the interviewer's plan and to formulate a list of general guide questions, around which the remaining interviews were to be centered. Also during these interviews, the attitudes of the pupils toward this type of questioning was carefully observed. These observations showed the pupils to be cooperative and willing to discuss freely the questions asked.

After combining and summarizing the comments of the pupils recorded in these first interviews, the following list of questions was made:

1. Do you like mathematics?

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[1] Hartmann, George W., "The Interview as a Research and Teaching Device," Journal of Applied Psychology 17:208-209 April,1933.

[2] Bingham, Walter Van Dyke and Moore, Bruce Victor, "How to Interview" Harper and Brothers, New York, 1931.

[3] Garrett, Annette Marie, "Interview, Its Principles and Methods," Family Welfare Association of America, New York,1942.

2. What are some of the ways that you have been taught the mathematics you have taken?
3. Which of these methods and techniques do you prefer?
4. Which of these methods and techniques do you feel were most valuable to you?
5. In what way should the blackboard be used, and how valuable is this work?
6. What is your opinion about the value of homework, and how it should be used?
7. Should the teacher follow the text closely or not?
8. In what ways, if any, do you think the way of teaching mathematics could be changed to help pupils more?

The order of the above questions was not followed strictly, and in some cases it was not possible to ask all of them. Also, in cases where the pupil seemed in doubt as to what was meant by the questions asked, they were rephrased into different form. For example, if a pupil seemed hesitant over questions three or four, these questions would be reworded to eliminate the words "methods" and "techniques" and substitute the word "ways" as used in question two. Another example would be question number eight. Pupils sometimes wanted to give answers to this in terms of answers to questions five, six, and seven, and it was sometimes necessary to remind them that it was very possible that the same answer might be given to one of these and also to number eight.

Reasons for interviewing pupils in pairs have already been given. Since the usual method is to interview single

persons, further explanation of the practice followed in this study will be given. In five of the first fifteen experimental interviews, the pupils were taken singly, in order that these interviews and the answers obtained could be compared with those in which the pupils were taken in pairs. As a result of these comparisons, it was found that single pupils were more suspicious, timid and unwilling to speak as freely as the pupils in pairs. Also in overcoming these difficulties with single pupils, the time allowed for the interview was nearly consumed before rapport had been established.

The time allowed was from ten minutes to a half hour for each interview, depending upon the length of time necessary to reach a free discussion of the main questions. When the pupils were paired, they were soon at ease, and the guide questions could be presented early in the interview. Also the comments of these pupils were stated more frankly and fluently than were those of the single pupils.

A criticism of using the method of pairing pupils was that pupils would tend to agree with each other, and each interview would yield only one, rather than two opinions. The results of the interviews show that this was not true. Strong disagreement, backed by definite statements was often found between the two pupils being interviewed. Samples one and two in the appendix are illustrations of this. In Group I the pupils disagreed as to whether the teacher should follow the text

closely or not. In Group II the opinion of pupil #2 was that "homework should be explained before it is done and taken up afterward," while #1 expressed a contrary opinion by saying, "No, I think only before, then pass it in and forget about it." Another example of this, not shown in the appendix, was concerning method in solving problems. In this interview #1 said, "there should be a definite way to do problems and pupils should have to follow it." Pupil #2 insisted that "it is not good to have a set way of doing things, because then pupils won't think for themselves."

A comment made by one pupil would often suggest a related point to the other, and as a result more points were covered in each interview without the use of the guide questions. The readers attention is again called to the appendix (Group II) for an example of this, where a comment on the use of practical illustrations stimulated another on using practical formulas instead of artificial ones. A further illustration of this is seen in another interview where the first pupil suggested that "pupils should be allowed to work at the board so that their mistakes can be discovered." The second pupil's follow-up remark was, "Yes, and the class should do most of the explaining of these mistakes."

In the interviews, the interviewer introduced himself to the pupils, telling where he was from and the purpose of the interview. The pupils were told not to give their names, in closely or not. In Group II the opinion of pupil #2 was that "homework should be explained before it is done and taken up afterward," while #1 expressed a contrary opinion by saying, "No, I think only before, then pass it in and forget about it." Another example of this, not shown in the appendix, was concerning method in solving problems. In this interview #1 said, "there should be a definite way to do problems and pupils should have to follow it." Pupil #2 insisted that "it is not good to have a set way of doing things, because then pupils won't think for themselves."

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In the interviews, the interviewer introduced himself to the pupils, telling where he was from and the purpose of the interview. The pupils were told not to give their names, in order that they might know that their comments would have no bearing upon their school grades. They were also asked to refrain from referring to any particular teacher by name. The purpose of the study was not to "check-up" on pupils and teachers, but to obtain pupils' opinions on the techniques and procedures of teaching.

The comments of the pupils were recorded in paragraph form during the interviews, with the pupils designated as number one and number two. These comments were afterward put into the tabular forms of Chapter III.

Description of Schools and Distribution of pupils surveyed. The study was carried out in four large schools (over 1000 pupils) near Boston, Massachusetts. The schools selected were Belmont, Brookline, Malden, and Somerville Senior High Schools. They were selected to represent populations ranging from the industrial sections to the wealthier residential sections, in order that a wide variety of pupils could be sampled. The schools themselves, however, were about equal as far as physical makeup and number of staff were concerned.

The survey included 354 pupils from the ninth, tenth, eleventh, and twelfth grades, with the greater percentage coming from the eleventh and twelfth. In the early interviews, the pupils were selected in about equal proportion from all four grades. The results of the interviews showed that although the ninth and tenth graders had definite opinions, they were

not as fluently expressed nor were there as many as from eleventh and twelfth graders. It was also found that the main questions of the interview could be approached much more quickly with the eleventh and twelfth grade pupils. For these reasons the majority of the pupils for the interviews were taken from the two upper grades, although some were still taken from the tenth grade when school schedules prevented using the other classes at the desired times. No distinction is made between grade levels in the results, and none between boys and girls.

The pupils were selected in random pairs from classes in first and second year algebra, plane geometry, solid geometry and trigonometry, and general mathematics. To further explain the shift in proportion to eleventh and twelfth grades, it will be pointed out that these math students had also had the first and second year courses before taking the advanced work, and that all pupils were asked to speak in terms of all the mathematics courses they had had in senior high school.

The procedure was for the teacher to select two at a time at random for an interview, and to replace them with two others when they returned. The cooperation of teachers did much to make the study successful, as did the help of administrators in providing pleasant offices for the interviews.

CHAPTER III

ANALYSIS OF DATA

Scope of the Chapter. The material in the following pages is an analysis of the opinions of 354 senior high school pupils who were interviewed by the writer and whose comments were recorded in paragraph form during the interviews. The opinions were first tabulated from the interview sheets and then the items were grouped into the following tables. The chapter presents these tables with explanations of their content. The frequencies in the tables represent the total number of times that comment was given as an opinion. The percentages are based upon the total number of times that all the comments in a given table were made. Since the nature of the data prohibits any further statistical treatment, the conclusions of the study are based upon these frequencies and percentages.

Pupils' Comments related to general methods. In the study, many of the comments were in terms of general methods of teaching that would apply as well to other subjects as to mathematics. These comments are summarized in Table I, and the grouping of the items can be seen from a study of the table. A total of nineteen comments were made and these were found 267 times. The percentages are based upon this total number of times that all comments are made.

Table I. Summary of Pupils' Comments Related to General Methods of Teaching

Comment	Number of times made	Percentage of 267 times
A. Teacher's Role in the Classroom	137	51.3
1. More time and willingness to answer pupils' questions.	56	20.9
2. Give individual help to pupils.	49	18.4
a. Through supervised study in class	26	9.7
b. After school	23	8.7
3. Teachers shouldn't assume pupils know too much in the beginning.	17	6.4
4. Should be more teacher questions and less lecturing.	10	3.7
5. Teachers should realize all pupils can't do the same work.	5	1.9
B. Pupil's Role in the Classroom	93	34.9
1. All pupils should have a chance to talk	79	29.6
a. General class discussion	55	20.6
b. Do some of the explaining individually	15	5.6
c. Allowed to correct teacher's mistakes	4	1.5
d. Give suggestions for things to do	3	1.2
e. Teach occasionally	2	.7
2. Pupils should be allowed to think for themselves	5	1.9
3. Pupils should be kept after school if lesson isn't properly learned.	5	1.9
4. Pupils don't know how to study and should be taught how.	4	1.5
C. Comments on Planning	37	13.8
1. Speed of progress	27	10.1
a. Teachers go too fast	22	8.2
b. Teachers go too slow	3	1.2
c. Speed is irregular	2	.7
2. There should be a variation from day to day in teaching.	8	3.0
3. There is too much difference in methods from year to year.	2	.7
Totals	267	100.0

The comments are classified in three main areas, and an analysis of Table I shows that 51.3% of the total comments were in terms of the teachers' role in the classroom. Of this 51.3%, the larger part is concerned with direct teacher assistance to pupils, through answering of questions and supervised study. The comments of pupils that deal with the pupils' role in the classroom are predominantly preferences for pupils being given a chance to talk (29.6%). It can be seen that nearly all the remaining comments are concerning the speed of progress of the work. The number of students commenting upon this was small, but of those doing so the opinion was that teachers make the work go too fast.

Pupils' comments related to methods of teaching mathematics. In contrast to Table I, the comments summarized in Table II give the opinions of pupils related to methods of teaching mathematics. Both tables are phrased in terms of the comments as they came from the pupils. Main headings are the author's groupings, while sub-headings are the pupil's own comments. Not all comments on the same thing were phrased in the same way, but the phrasing was used which was most frequently given by the pupils. The information in Table II shows that 88.9% of all comments related to methods of teaching mathematics are concerned with mastery of the subject matter, and applications and illustrations. Pupils consider that more and better explanation by the teacher is most helpful in mastering the subject

Table II. Summary of Pupils' Comments Related to Methods of Teaching Mathematics

Comment	Number of times made	Percentage of 696 times
A. Mastery of Subject Matter.	328	47.3
1. More explanation of all topics by teacher.	200	28.7
a. Visual explanation with diagram at blackboard.	45	6.5
b. Slow, careful explanation, clarifying each topic.	30	4.3
c. Teacher explanation is better than book.	22	3.2
d. No particular comment, just "Better teacher explanation"	103	14.7
2. Much review of previous work	47	6.8
3. Much drill and repetition	21	3.0
4. Work on each topic until learned thoroughly	21	3.0
5. Should be taught how to reason, not just learn theorems and rules	9	1.3
6. Teacher should be willing to go over work not understood.	8	1.2
7. More learning of rules	8	1.2
8. More derivation of formulas in algebra.	6	.9
9. Less exactness in written work	6	.9
10. Teacher should not make the work too mechanical.	2	.3
B. Applications and Illustrations	290	41.6
1. More applications to and illustrations from everyday life.	285	40.9
2. Relate math more to other school subjects.	5	.7
C. Variety of Classroom Activities	78	11.1
1. Use notebooks to keep a record of new topics and rules.	28	4.0
2. Use models, pictures, and tricks demonstrated by the teacher.	19	2.7
3. Competition thru games, contests.	12	1.7
4. Classwork to replace homework.	6	.9
5. More oral classwork.	5	.7
6. More written work at seats.	4	.6
7. Learn some of the history of mathematics.	2	.3
8. Use films in math as in other classes.	1	.1
9. Have field trip occasionally.	1	.1
Totals	696	100.0

matter. The pupils were asked what kind of explanation they considered a good one, and the subheadings indicate their responses. The majority didn't have a special comment, but still wanted more thorough explanation. It is interesting to note that a fairly large part of the group considered "review of previous work" and "drill and repetition" as important in getting the subject. Part C of Table II has listed all the suggestions given by pupils to give variety in the classroom activity. Item 1 was given in terms of what the class was doing at the time, so the question concerning notebooks was not asked directly of all pupils. The comments with smaller frequencies can be read directly from the table.

Opinions on using the blackboard and textbook, and on homework. Tables III, IV, and V are the opinions given in answer to the specific questions listed in the interview

Table III. Opinions of 354 Pupils on Use of the Textbook

Opinion	Number of times given	Percentage of 354
1. Teacher should not follow the text closely.	122	34.5
2. Teacher should follow the text closely.	88	24.8
3. No preference.	104	29.4
4. No opinion	40	11.3
Totals	354	100.0

guide on pages 8 and 9 of the thesis. All pupils gave an opinion on the use of the text, and these are summarized in Table III under the four possible replies to the question. It can be seen from the table that there is little difference in the preferences expressed, but that the largest percentage (34.5%) preferred not following the textbook too closely. Some of the pupils defended their answer with such statements as those given in the examples of the appendix.

Table IV. Pupils' Opinions on Using the Blackboard

Opinion	Number of times given	Percentage of 297 times
A. Value of blackboard work.	250	84.2
1. Pupil boardwork has the most value	140	47.2
2. Teacher doing the boardwork has the most value.	100	33.7
3. Boardwork is valuable only to those at their seats.	10	3.3
B. Method of handling boardwork. (General Comments.)	47	15.8
1. Teacher should do all the boardwork, discussing it with class.	13	4.4
2. All pupils should do boardwork each day.	12	4.0
3. Diagrams and "blueprints" of the problems should be put on blackboard wherever possible.	11	3.7
4. Pupils should work one at a time at the blackboard.	7	2.4
5. Pupils should not be forced to work at the blackboard.	3	1.0
6. Teachers shouldn't interrupt too much when pupils are doing blackboard work.	1	.3
Totals	297	100.0

The opinions having to do with use of the blackboard were given almost wholly in terms of who should do the blackboard work in order to get the most value from it. Only 15.8% of all comments fall outside this group, and these are classified under "method of handling boardwork." These percentages concerning blackboard work can be seen in Table IV. The breakdown shows that 47.2% of the comments favored pupil boardwork as most valuable, while 33.7% considered that it was more valuable to have the teacher do the boardwork.

The comments received in answer to the question about homework were much more numerous and more definitely stated. Table V shows that the larger part of the total comments was almost evenly divided between "value and importance of homework," and "discussion of homework." The largest frequency of all comments in this table was that of the necessity and value of homework in learning mathematics. This frequency of 230 shows that 65% of the total group interviewed regard homework as necessary to the thorough learning of a mathematics subject. In comments made on discussion of homework, 33.3% of the total 44.7% were in favor of discussion of the homework after it has been worked by pupils. Of this 33.3%, over half, or 19.6%, want it discussed only after it is done, while the remainder wish to have it discussed both before and after. A very small number of comments favored having the homework assigned only, and not taken up or discussed in any way. Parts C and D of

Table V. Pupils' Opinions Concerning Homework

Opinion	Number of times given	Percentage of 539 times
A. Discussion of Homework.	241	44.7
1. Should be discussed after it is done only.	105	19.6
2. Should be discussed both before and after it is done.	75	13.7
3. Should be explained and discussed before it is done only.	53	9.9
4. Should not take too much time on discussion.	5	.9
5. Should not be discussed at all, only assigned.	3	.6
B. Value and Importance of Homework.	240	44.5
1. Necessary and valuable in helping us learn.	230	42.6
2. Could be replaced with something else.	8	1.5
3. Not valuable and should be omitted.	2	.4
C. Type of Homework.	32	6.0
1. Should not be too much memorization and drill.	8	1.5
2. Only the hard ones should be assigned.	7	1.3
3. Should include both old and new problems.	4	.7
4. Should have variety in assignments.	4	.7
5. Should have long term assignments to be done at our convenience.	3	.6
6. Extra honor work should be voluntary, not assigned.	3	.6
7. Some homework should be construction of models.	3	.6
D. Administration and Quantity Assigned.	26	4.8
1. Part of homework should be done in class.	11	2.0
2. Homework should all be corrected and passed back.	8	1.5
3. Too much is assigned.	5	.9
4. Too little is assigned.	1	.2
5. About the right amount is assigned.	1	.2
Totals	539	100.0

Table V include pupils' additional comments on the type of problems and work to be given as homework, and the administration and quantity assigned. The very small frequencies concerning the amount of homework assigned were included only to give the reactions of these few pupils toward the existing practices in their classes. The large majority of pupils made no comments whatever on these points, and the question was asked directly of none.

Pupils' comments related to problem solving and testing. Although the interviews were built around the guide questions listed in Chapter II, many other comments were made by pupils that did not relate to these questions directly and yet were part of the total opinions of pupils concerning teaching methods in mathematics. One group of such comments is shown in Table VI, and the comments are all related to problems in mathematics, and their solution. A very large part of the mathematics at the senior high school level is the solution of problems, and the table shows the preferences of pupils in this area. No leads were given to pupils to draw out these comments and yet a total of 65 pupils stated that the work in problem solving was the most valuable part of mathematics. In line with the preference for practical applications shown in Table II, some of the comments in Table VI state that problems should be practical also, and not stereotyped. Of the comments made concerning the method of solution of problems, equal numbers of pupils preferred having a set pattern for working problems

Table VI. Pupils' Comments Related to Problems and Problem Solving

Comment	Number of times made	Percentage of 158 times
A. General Comments.	86	54.4
1. Problem solving is the most valuable part of mathematics.	65	41.1
2. Problems should be practical, not artificial or stereotyped	12	7.6
3. Problems should be taught by type and not mixed up.	6	3.8
4. Each new type of problem should be explained on the blackboard by the teacher.	3	1.9
B. Method of Solving Problems.	46	29.1
1. Should use the same method or pattern in doing all problems.	17	10.8
2. Should not have to follow a set pattern.	17	10.8
3. Teacher should give method first.	7	4.4
4. Pupils should be allowed to use shortcuts.	5	3.1
C. Problem Work in Class.	26	16.5
1. Should be done at the blackboard by pupils.	12	7.6
2. Should be done at the blackboard by both teacher and pupils.	10	6.3
3. Should be done at the blackboard by the teacher.	3	1.9
4. Should be done at seats by pupils, both orally and written.	1	.7
Totals	158	100.0

and not having a set pattern. Some of the pupils who favored a set pattern for working problems said that "you know where you are if you do" and "it is less confusing to use a certain pattern consistently." Those favoring less definite methods of working problems said, "Why can't we use a different way once in a while, instead of following a five-step pattern in

all problems?" Also, "it would be a lot better to be allowed to use shortcuts, as long as we get the correct answer." The majority of comments concerning the handling of problem work in class, favored having some problems done by the teacher and some by the pupils, and most of the work done at the blackboard.

Fewer comments were made concerning tests and testing, and Table VII shows these comments to be dealing mostly with the length and frequency of the tests to be given. It can be seen that more students favor frequent than infrequent testing. Also it should be noted that some pupils felt definitely that tests

Table VII. Pupils' Comments Related to Tests and Testing

Comment	Number of times made	Percentage of 53 times
A. Length and frequency of tests.	37	69.8
1. Have both long infrequent tests and short frequent tests.	18	34.0
2. Have only short, frequent tests.	12	22.6
3. Have only long infrequent tests.	7	13.2
B. Preparation and Administration.	16	30.2
1. Tests should always be announced so that pupils can prepare for them.	7	13.2
2. More time should be allowed to do tests.	7	13.2
3. Multiple-choice tests aren't good for math.	1	1.9
4. Quizzes should be given over the homework.	1	1.9
Totals	53	100.0

should be announced in order that pupils might prepare for them. These pupils also made the complaint that most testees have, that more time is needed on tests to do the work.

Comments not directly related to teaching methods. Some of the pupils when questioned concerning their preferences in techniques and procedures, answered in terms of characteristics of the teacher, rather than a method which could be used by any or all teachers. The author felt that these comments were reactions to teachers which these pupils had had, and for this reason has classified them as shown in Table VIII. The table is constructed in the same manner as the preceding tables, and, since these topics were incidental, their consideration is left to the reader. The author would like to call attention to the fact that the largest percent in the table is that of the comment prefering a teacher who is a good disciplinarian. Pupils themselves are aware of the fact that a well-disciplined class is a better class in which to learn.

In addition to the comments and opinions thus far presented, a few additional comments were made concerning factors outside the teachers' control. These comments appear in Table IX, and serve to show that pupils are also aware of the problems which face administrators and school authorities.

Techniques and procedures preferred and valued by pupils. The problem of this study was to determine what the preferences of pupils were in techniques and procedures of teaching mathematics. The tables presented previously have given these pre-

Table VIII. Desirable Characteristics of Teachers Named by Pupils

Characteristic	Number of times named	Percentage of 84 times
A. Classroom Attitude.	6	7.2
1. Doesn't shout at pupils.	3	3.6
2. Has an interesting manner.	2	2.4
3. Doesn't have a superior attitude.	1	1.2
B. Teaching Ability.	39	46.4
1. Is a good disciplinarian.	26	30.9
2. Can get down to pupils' level.	5	5.9
3. Has thorough knowledge of subject.	3	3.6
4. Is honest as to what is hard and easy.	2	2.4
5. Does not ridicule poor answers.	2	2.4
6. Is not always trying to "catch" pupils.	1	1.2
C. Personal Characteristics.	39	46.4
1. Has a friendly attitude.	12	14.3
2. Is patient.	12	14.3
3. Is strict.	6	7.2
4. Makes pupils feel at ease.	4	4.6
5. Understands pupils' point of view.	3	3.6
6. Is not grouchy.	2	2.4
Totals	84	100.0

Table IX. Miscellaneous Pupil Comments Concerning Factors Outside the Teachers' Control

Comment	Number of times made	Percentage of 22 times
1. Classes too large.	11	50.0
2. Classes should be separated into faster and slower groups.	5	22.8
3. Text too difficult.	4	18.2
4. Sliding scale for marking not good.	1	4.5
5. Grades shouldn't be given wholly on the rank book, effort should be considered.	1	4.5
Totals	22	100.0

ferred and valued techniques and procedures, grouped under the headings to which they are related. These preferences are now summarized in Tables X and XI, with the listing of the first eleven preferences in Table X and the first ten methods in order of value given by pupils in Table XI. No percentages are given for these tables, because their purpose is only to indicate which of the methods occurred the most frequently in the comments of the pupils.

Table X. Pupil Preferences in Techniques and Procedures of Teaching Mathematics

Preferences	Number of Pupils
1. The Teacher should make many practical applications of mathematics.	285
2. The blackboard should be used a great deal by both teacher and pupils.	240
3. There should be slow, careful explanation of each topic by the teacher.	200
4. The textbook should not be followed closely.	122
5. Homework should be discussed only after it has been done by pupils	105
6. The textbook should be followed closely.	88
7. All pupils should have a chance to talk in some way in class.	79
8. There should be a variety in the classroom activities.	78
9. Homework should be discussed both before and after it is done by pupils.	75
10. Homework should be explained and discussed only before it is done by pupils	53
11. Pupils should have individual help, through supervised study in class and after school.	49

Table XI. Techniques and Procedures of Teaching Mathematics Considered Valuable by Pupils

Techniques and Procedures	Number of Pupils
1. Regular assignments of homework to be done by pupils and passed in.	230
2. Practical applications of mathematics made in class.	212
3. Slow, careful explanation of all topics by the teacher.	183
4. Blackboard work by pupils	140
5. Blackboard work by the teacher.	100
6. Much work in problem solving.	65
7. Enough time and willingness on the part of the teacher to answer all pupil questions.	56
8. Continual review of previous work.	47
9. Individual help for pupils during and after school.	40
10. Frequent tests over work covered.	30

The preferences do not total the number interviewed, because the purpose is not to determine a first preference of a given group, but to find out what methods are preferred by all pupils: Thus, for instance, in Table X, a pupil who stated that he or she preferred many practical applications of mathematics might also have expressed a preference for good teacher explanation. Also in Table XI, a pupil who considered regular homework assignments valuable, may have considered continual review of previous work as equally valuable.

It was necessary to make an arbitrary choice of the number of items to be included in Tables X and XI. In listing the preferences of Table X, the frequency below that of item number

eleven was 22, or less than half the next highest frequency of 49 for item eleven. Since the frequencies of preferences which were below 22 dropped in unit intervals, or nearly so, the number of items in Table X was fixed at eleven. The same procedure was followed with Table XI and the number of items limited to ten, since to add another item would have meant a sharp drop in the frequency.

The tables themselves are so worded as to be self-explnatory, and the reader can refer to them for the order of preference and value of the various techniques and procedures commented upon by pupils. Further mention of the items in these two tables will be made in the summary of the study.

CHAPTER IV

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

SUMMARY

The purpose of this investigation was to determine, through individual student interviews, the extent to which senior high school pupils are aware of the methods and techniques of teaching mathematics.

The survey was made upon 354 pupils from the ninth, tenth, eleventh, and twelfth grades in four high schools of over 1000 students each. An analysis of the results of the interviews showed that all of these pupils had at least one definite opinion concerning some area of mathematics teaching method.

A total of 76 different comments and opinions was obtained in six areas directly concerned with methods of teaching mathematics. An additional 39 comments were obtained upon Teacher Characteristics, Factors Outside the Teachers' Control, and General Methods of Teaching.

The preference in techniques and procedures of teaching mathematics that was most frequently expressed was for "more practical applications of mathematics by the teacher." Two hundred eighty-five pupils, or 80.5 percent of those participating in the study, gave this item as a preference.

A preference for "extensive blackboard work by both teacher and pupils" was expressed by 67.8 percent of the pupils, and

56.5 percent also preferred to have teachers give "slow, careful explanation of each topic."

The only question in the interview guide calling for a "yes" or "no" answer was "Should the teacher follow the text closely or not?" Answers to this question were received from all pupils surveyed, and a ten percent difference was found in favor of "not following the text closely." The exact percentages for the different answers are as follows: 34.5 percent preferred not to follow the text closely, 24.8 percent preferred to follow it closely, 29.4 percent had no preference for either, and 11.3 percent had no opinion on the question.

Thirty percent of the pupils preferred to have the regular homework discussed only after it had been done, as compared with twenty-one percent who preferred to have it discussed both before and after.

The replies to the question, "What techniques and procedures of teaching mathematics are most valuable?" indicated that pupils considered "regular assignments of homework" to be of most value. Two hundred thirty pupils, or 65 percent of the total group, considered this a valuable and necessary aid in learning mathematics.

The frequency of 212 for value of applications indicates that while pupils prefer this technique, they consider it less valuable than the regular homework assignments.

"Slow, careful explanation by the teacher," which was third in the list of preferences, was also third in the list of tech-

niques and procedures considered valuable.

Thirty-nine percent of the pupils considered blackboard work done by pupils valuable, while twenty-eight percent valued that done by the teacher.

The author would also like to summarize briefly, a few important points concerning the interviewing in the hope that these suggestions may prove helpful to the successful completion of other such studies. Pupils were very willing to cooperate when told the purpose of the interviews. The majority of pupils appeared very pleased that they were being asked opinions on such questions as these, and their reactions indicated interest and sincerity. No loss of information, and a great saving of time and effort resulted from the recording of comments while the interview was in progress. Experiment showed that for such interviews pupils could be taken in pairs and still give separate opinions. This meant a great saving of time, because rapport was established much quicker. For this type of interview, the pupils are more at ease if the questions are asked at random, rather than from a prepared written form.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

The findings of the study suggest the following conclusions. The study shows conclusively that pupils at the high school level are very much aware of the methods by which they are taught mathematics, and that they have very definite opinions

concerning which methods they prefer and which have the greatest value in helping pupils master the subject.

Information obtained indicates also that factors concerned with organization and administration are of major interest to pupils.

The fact that 285 pupils out of a group of 354 want more practical applications in the teaching of mathematics, indicates that pupils themselves are desirous of getting a mathematics which will have a utility value when they leave the high school. It would be possible to utilize the resources of the school and the community, as well as the teachers' own initiative in giving pupils this practical mathematics for which they express a preference.

No significant conclusion can be made as to whether the textbook should be followed strictly in mathematics or not. The larger percentage of pupils favored supplementing the textbook with outside reading, the teachers' own ideas and other mathematics texts. However, the difference in percentages of these two preferences is too small to substantiate a definite conclusion.

Pupils value the regular assignment of homework, but want variety in assignments as well as in the classroom activities. A swing away from the regular textbook assignment is necessary to meet the preferences of pupils.

The proper use of the blackboard is an essential in the minds of the pupils. Teachers must use careful judgment as to what to put on the blackboard themselves and what to have put on by pupils.

In order to meet fully the needs of all pupils, the teacher must take sufficient time and be willing to recognize and answer all pupil questions. Individual help for pupils is much preferred, and this can be given both in class and in the after school session.

A need for much review work and work in problem solving is indicated, and also for a better testing program in which all the work covered is tested at regular intervals.

The author makes the following suggestions for further study in this area.

1. A questionnaire study based on the first five or six preferences and the same number of valued techniques would give more conclusive data about these preferences and valued techniques if a large enough population were surveyed.
2. An investigation of the preferences of high school pupils in type of homework assignments is suggested by the comments on type of homework.

Although attitude and opinion surveys of pupils have been numerous in recent years, a review of the literature showed that the subject of mathematics has been investigated far less extensively than most other fields. The author feels that the method of investigation of this study would be very useful in determining pupil reactions to other elements in the teaching of secondary mathematics.

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APPENDIX

SAMPLES OF PUPILS' COMMENTS AS RECORDED DURING INTERVIEWS

The following summaries are the reports of pupils' comments as given by pupils themselves and noted by the interviewer during the interviews. The first two samples of two pupils each, were chosen because they were judged to be very good interviews. The second two were chosen to represent poorer interviews in which the opinions given were fewer and less definite.

<u>Group I</u>: (#1) Problem work is the most valuable. (#2) Doing homework after explanation is the most valuable for me. (#1) Teachers should follow the book closely, so that you'll know where you are. (#2) No, the teacher can make the work simpler than the book. (#2) The teacher should give personal help at the desks while some are at the board. (#1) Making applications to everyday life helps a lot. (#2) Yes, something like you wouldn't get in the book. (#1) Too much time should not be spent on homework in class. (#2) Let pupils talk with each other about homework. (#1) A slow, careful explanation of new topics helps me a lot.

<u>Group II</u>: (#1) The most helpful thing done in mathematics classes is problem solving with a definite pattern to follow in solving them. (#2) A lot of boardwork is the most help to me. (#2) I can't study from the book so easily. The teacher's explanation is better. (#1) A better explanation of things would help most of the time, like using models or diagrams to show something. (#1) Practical examples are a big help, but teachers don't do this much. (#2) Teachers should use practical formulas

in class instead of artificial ones. (#1) Going outside the building as a class to do something would be a big help in learning something new. (#1) Mathematics should help you to think. (#2) Homework should be explained before it's done and taken up afterward. (#1) No, I think only before then pass it in and forget about it. (#2) A good teacher makes the pupils feel at ease.

Group III: (#1) Go over the homework in class, better than giving exams. (#2) The most helpful thing is review work. (#2) Teachers shouldn't be grouchy. (#1) All teaching is about the same, so it doesn't matter much. (#2) Yes, school is school no matter how you look at it.

Group IV: (#1) I suppose some teaching is different from others but I never thought much about it. (#1) Teachers should follow the book closely. (#2) Yes, then the pupils know where they are. (#2) I can't think of anything special to say about how math is taught or should be taught. It's like any other school subject and you have to take it as the teachers give it.