

NEW MATHEMATICS IN GUJARAT

A Report on the Project for Teaching
of Algebra at Standard VIII : 1964-67
Submitted by K. B. SHAH

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COMMUNITY SCIENCE CENTRE
SANSKAR KENDRA
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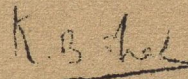
OCTOBER 1968

PREFACE

This is a report of the 1964-67 project for teaching of Algebra at standard VIII, initiated by the Group for Improvement of Science Education and continued - expanded by the Community Science Centre. Supported by local efforts, this was a unique project undertaken in India by a group of motivated teachers. Starting from Ahmedabad the project expanded over the whole State of Gujarat within a span of four years. It being one of a very few of its type, we hope the report of this project will prove as useful in all its aspects as it has been to all those who participated in the same.

I take this opportunity to express my sincere thanks to all my colleagues, who helped us in developing this project and to all those numerous students and teachers who played a very important role in making this project meaningful.

OCTOBER 20, 1968.


(K.B. SHAH)
DIRECTOR.

COMMUNITY SCIENCE CENTRE
AHMEDABAD 6

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1 BACKGROUND :

To keep pace with the new developments in science and technology, a good deal of efforts are being made for improving science education at all levels. All developments and researches in science depend in one way or the other upon mathematics. With rapid advances in the field of science and mathematics, a need is being felt everywhere to correlate our teaching at secondary schools with new knowledge developed in these fields.

To focus attention on this issue, a two days seminar was organised under the joint auspices of the Group for Improvement of Science Education (GISE), A.G. Teachers' College and the Ganit Mandal of Ahmedabad on 21st and 22nd September 1963. As a result of deliberations at the seminar, it was decided to start a project on teaching Algebra at standard VIII with modern approaches based on the Set theory. The Group for Improvement of Science Education, then working under the aegis of the Physical Research Laboratory, Ahmedabad undertook all the responsibilities of organising and implementing the project. With the setting up of the Community Science Centre at Ahmedabad in June, 1966, the project was then carried on and expanded by the Centre.

2 OBJECTIVES OF THE PROJECT :

The implementation of the project was based on the following objectives :-

- (1) To introduce modern approach of teaching Algebra in standard VIII on an experimental basis working within the limits of the syllabus prescribed by the State Government.
- (2) To attempt to correct a considerable amount of misconceptions developed in the minds of the students.

- (3) To present the subject as an integrated part of mathematics based on theory of Sets.
- (4) To create an atmosphere suitable for introducing innovations in the mathematics curriculum at the school level.
- (5) To remove the prevalent misconception that basic and therefore abstract mathematical notions cannot be grasped by school-age children.
- (6) To know the reactions of the teachers, students, head masters and parents about the new approach and thereby to know the extent of feasibility of introducing this approach on a wider base.

In achieving these objectives, the following procedure was followed.

5 PROCEDURE :

(i) PREPARATION OF TEXT-BOOK MATERIAL

The first and the most important aspect of the project was to develop some material in regional language which can be used by the students. This work was entrusted to Shri G.A. Dalal, Principal of C.N. Vidyalaya, Ahmedabad, who had then attended the 1963 summer institute in Mathematics. All the manuscripts written by him were scrutinised by a University Professor of Mathematics. The revised material was then presented before a group consisting of University and College teachers and of Algebra teachers of the participating schools. A representative list of persons involved in this group is given in Appendix I. The matter was further revised in light of the discussions and suggestions. Finally, a text book on Algebra for standard VIII was evolved and first published in June 1964 by the Group for Improvement of Science Education for the use of the students and teachers participating in the 1964-65 project. This edition was revised in June 1965 in light of the feed-back from the project teachers and students and was further revised in June 1967.

Though working within the limits of the State Syllabus for Algebra for standard VIII, the text included the language of the Set theory and some fundamental concepts of Mathematics. Appendix II describes the subject matter presented in the text.

In order to reach a larger number of teachers implementing the project all over the State of Gujarat in the year 1967-68, a teacher's hand book was also published in June 1967. The material included in the Teachers' Guide is described in Appendix III.

(ii) TRAINING OF TEACHERS

Along with the preparation of the text book, the teachers for the first year project were trained through seminars, discussions and week-end orientation courses. This was possible without any extra expenditure as all these teachers were in Ahmedabad. They thoroughly discussed the content and the new approaches presented in the text book. Occasional meetings during the running of the project in course of the academic year were also arranged to get the feed-back from the teachers and students.

This process of the training of the project teachers could not be followed when, in 1966-67, the project was given to schools out of Ahmedabad. It was very difficult to get the project teachers from distant places during the working sessions. The burden of T.A. and D.A. for these teachers was also there. As a result, only three two-day seminars were possible. The first in June 1966, the second in October 1966 and the third one in February 1967. The Teachers' Guide was not available then. Due to this, we feel that most of the project teachers were not adequately oriented nor were satisfactorily trained for handling the new material developed in the project. This lack of sufficient orientation of the project teachers has certainly influenced the implementation of the project. (See section 5 on 'Evaluation' for further discussion on this aspect).

This difficulty forced us to publish the Teachers' Guide for the project in June 1967. In the year 1967-68, the project included about 120 teachers who were all supplied with the Teachers' Guide and no orientation seminars were conducted.

(iii) IMPLEMENTATION OF THE PROJECT

To put the project on formal lines for the purpose of school administration, the Director of Education of the Gujarat State was approached and a permission was obtained for running the project in some selected secondary schools and for using the text book of Algebra for standard VIII published by the Group for Improvement of Science Education.

For selection of the schools, a circular was sent to the heads of the local schools for knowing their willingness to participate in the project. Only those schools were selected which fulfilled the following requirements :-

- (1) The teacher and the head master both must be quite willing to take up the project.
- (2) The head of the school will provide full facilities to teachers in teaching and testing.
- (3) At least two teachers will be deputed by the school for training so that one can be substituted in absence of the other.
- (4) Teachers deputed for the project will teach to the project students for the whole year.

The following table gives yearwise number of schools and students who participated in the project :

<u>YEAR</u>	<u>NO. OF SCHOOLS</u>	<u>LOCATION</u>	<u>NO. OF STUDENTS</u>
1964-1965	9	Ahmedabad	517
1965-1966	10	Ahmedabad	500
1966-1967	12	Outside Ahmedabad	800
1967-1968	65	Distributed all over the State.	4,000

The project teaching was carried out during the regular periods allotted for the teaching of Algebra and no special/extra periods were used.

4 FINANCE :

The Group for Improvement of Science Education received a grant from N.C.E.R.T. for printing the first edition of the text-book for standard VIII in 1964 and the text book was supplied free of charge to participating students. For the subsequent editions, the publication was made self-dependent and the project text books were sold at a reasonable price to the students.

5 EVALUATION :

It is necessary to evaluate any programme in terms of its objectives and the learning experiences provided to the participants. For this purpose, every year, monthly, terminal and annual tests were taken independently by each school for regular assessment of achievements of the students participating in the project. Moreover, in September, 1964, a common test was given to all the project students, the analysis of the results of which is given in Table I. For the annual examination in April, 1965, each project school set its own paper in Algebra at standard VIII, which was given to the project as well as to the non-project students in the same school. The statistical analysis of the results of these annual tests is given in Table II.

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TABLE I

School	CLASS- INTERVAL OF MARKS-										Total No. of students	CLASS Mean	Standar Deviasi
	0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30			
A	1	2	16	12	9	1	-	1	-	-	142	10.43	3.6
B	1	-	5	17	14	2	1	1	1	-	42	12.35	3.9
C	3	6	15	6	2	2	-	-	-	-	34	8.36	3.6
D	-	8	4	11	9	11	4	-	-	-	47	12.47	4.7
E	1	-	3	14	11	8	3	1	1	-	42	13.79	4.3
F	-	1	1	6	9	8	8	8	5	2	48	18.02	5.6
G	-	2	2	12	14	25	16	10	6	-	87	17.06	4.8
H	-	1	10	11	22	10	19	10	9	-	92	16.61	5.5
I	-	3	7	14	18	19	13	8	1	-	83	15.32	4.8
<hr/>													
Group	6	23	63	103	108	85	64	39	23	2	517	14.63	5.5
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TABLE - II

ANALYSIS OF RESULTS OF THE COMMON ANNUAL 1965 APRIL
EXAMINATION OF PROJECT AND NON-PROJECT STUDENTS IN
STANDARD VIII

<u>School</u>		<u>No. of students</u>	<u>Mean out of 100 marks</u>	<u>S.D.</u>	<u>'t' Ratio for significance of the difference</u>	<u>Remarks</u>
A	Project students	48	23.5	32.6	- 0.174	Not significant
	Non-project students	42	24.3	20.0		
B	Project students	89	23.1	23.5	- 1.21	Not significant
	Non-project students	43	28.5	23.6		
C	Project students	87	34.08	22.3	-	-
	Non-project students	-	-	-		
D	Project students	50	31.2	26.3	- 0.16	Not significant
	Non-project students	49	32.1	29.1		
E	Project students	83	44.3	25.5	+ 1.23	Not significant
	Non-project students	45	39.0	22.0		
F	Project students	42	36.7	25.0	+ 1.398	Not significant
	Non-project students	117	30.3	26.6		
G	Project students	33	30.76	26.95	+ 4.074	Significant at .01.
	Non-project students	86	10.81	13.08		
	Project classes	432	32.269	25.6	+ 3.169	Significant at .01.
	Non-project classes	382	26.001	23.97		

All the 't' ratios except for school G are not significant. The mean achievement of the non-project students in school G is very low and hence the 't' ratio has become significant, which in turn is responsible for making 't' for the whole group to be significant. In addition, it should be noted that the mean achievement of the project class of the school G is not very high and is actually lower than that of other four schools. Hence it is not wise to conclude from this table that the 't' ratio is significant for the whole

group because this is influenced by very low achievement of one particular group of students, which may be due to defective grouping of the students or poor teaching and learning experiences provided to that group. From the analysis, we can reasonably infer that there is no real difference between the mean achievements of the project and non-project groups. This therefore supports the feeling that the project has been useful in introducing some of the abstract notions of the new mathematics and in innovating its new approaches without damaging the general achievement standard.

In the year 1965-66, the project was repeated by most of the teachers who participated earlier. No detailed evaluation of this year's project was undertaken. However, the project teachers were highly satisfied with the general results.

In the year 1966-67, the project was undertaken in schools out of Ahmedabad and the quantitative evaluation was done separately by each school by giving a common paper in Algebra to the project as well as non-project students in standard VIII. The analysis of the data received from this examination is represented in table III.

TABLE - III

ANALYSIS OF THE DATA RECEIVED FROM THE
COMMON ANNUAL EXAMINATION TAKEN IN APRIL, 1967

<u>School No.</u>	<u>Nature of group</u>	<u>No.</u>	<u>Mean</u>	<u>S.D.</u>	<u>'t' ratio for difference between means</u>	<u>Remarks</u>
1	Project	34	8.617	5.25	- 1.106	Not significant
	Non-project	37	10.243	7.00		
2	Project	41	7.49	5.40	+ 1.597	Not significant
	Non-project	39	5.59	5.15		
3	Project	87	8.26	4.75	- 6.403	Significant at .01
	Non-project	85	13.77	6.40		
4	Project	42	6.88	4.7	- 1.29	Not significant
	Non-project	45	8.83	6.35		
5	Project	39	8.03	4.10	+ 0.027	Not significant
	Non-project	39	5.59	3.95		

Contd.....

<u>School No.</u>	<u>Nature of group</u>	<u>No.</u>	<u>Mean</u>	<u>S.D.</u>	<u>'t' ratio for difference between means</u>	<u>Remarks</u>
6	Project	44	13.25	7.30	- 2.80	Significant at .01
	Non-project	41	16.39	5.85		
7	Project	44	10.98	5.35	-	-
	Non-project	-	-	-		
8	Project	83	14.77	9.40	+ 2.932	Significant at .01
	Non-project	84	10.87	7.70		
9	Project	20	13.25	5.9	- 2.81	Significant at .01
	Non-project	20	15.5	6.9		
10	Project	25	13.00	6.33	+ 0.082	Not significant
	Non-project	88	8.31	6.33		
11	Project	40	11.25	5.19	+ 1.77	Not significant
	Non-project	46	9.07	6.26		

Five 't' ratios are in favour of project students and five of them are in favour of non-project students. But out of the five in favour of project students, only one is significant while out of those five in favour of non-project students, three are significant and hence it may be concluded with some reservations that the non-project group seems to be better in terms of achievement on common conventional Algebra test. This might be because the project was spread over a wider range of distances throughout the State of Gujarat and hence it was not possible for the project teachers to meet often and exchange their experiences and views through discussions. It was also not possible to run more refresher courses of longer duration and hence the teachers might have remained inadequately oriented for handling new material. Nevertheless, the gap is not so wide that it cannot be overcome by sufficiently orienting the teachers and by giving them the scope to discuss often among themselves the difficulties encountered in the implementation of the project. It also strongly advocates the point that the project cannot be truly evaluated by giving conventional tests to the project students.

This analysis, therefore, strongly suggests that for any experimental project of this type distributed over a whole State, the following measures become essential :

- (1) A good student-text,
- (2) Resource material for the teachers, in form of a teachers' guide,

- (3) Newsletter for the teachers discussing problems connected with the implementation of the project, feed-back from teachers and students, etc. and
- (4) Special tests - examinations for the project students.

6

QUALITATIVE EVALUATION OF THE ALGEBRA PROJECT
CONDUCTED OUTSIDE AHMEDABAD DURING 1966 -1967

The following is a qualitative evaluation of the Project conducted during the year 1966-1967 in which about 800 students from 12 schools, distributed all over the State of Gujarat participated. Questionnaires were distributed to the participants and responses were received from 60 students (taking 5 to 6 from each school), 22 teachers (two from each school) and 12 head-masters of the participating schools.

The sample taken for this evaluation is rather small for drawing sufficiently reliable inferences. However, it gives a fair amount of data for qualitative interpretation which can be used in the follow-up programme.

A. RESPONSES OF STUDENTS

Sr. No.	Questions	Frequency	
		Yes	No
1	Did you read the text-book?	59	1
2	Did you enjoy reading the book?	57	3
3	Could you understand while reading?	54	6
4	Did you enjoy learning Algebra?	54	6
5	Could you understand the idea of Set?	57	3
6	Would you participate next year if this type of teaching of Algebra is continued in standard IX?	54	6
7	Is it necessary to give answers in the text-book?	33	27
8	Would you advise your friends to participate in the project in standard VIII next year?	55	5

CONCLUSIONS :

From the above table it is clear that most of the students responded positively to all the questions except to question No.7. Hence it is reasonable to conclude that -

- (1) the students liked the new material,
- (2) the material is within the reach of the grasping ability of the students and
- (3) the responses to question No.7 forces us to reconsider the aspect of not giving all the answers in the text book.

B. RESPONSES OF THE TEACHERS

I. GENERAL INFORMATION ABOUT TEACHERS :

- (1) Fairly experienced teachers participated in the project. The average teaching experience of a teacher was about 8 years.
- (2) All teachers who participated were professionally trained.
- (3) Out of the 22 teachers, who responded to our questionnaire, 6 studied Mathematics upto Pre-university class, 10 studied Mathematics upto First Year of the Degree course and 4 were Mathematics Graduates. Information in case of two teachers was incomplete.

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II. REACTIONS OF THE TEACHERS :

Sr. No.	Questions	Frequency	
		Yes	No
1	Were the students interested in learning about Sets?	20	2
2	Are the students able to solve the test items based on Sets?	19	3
3	Is the method of incomplete sentences helpful and simpler in solving problems?	20	2
4	Was the chapter on Graphs taught?	5	17
5	Is there any difficulty in teaching the chapter on Graphs?	17	5
6	Do you believe that the project was successful?	12	10
7	Do you believe that this text-book should be introduced in all the classes of Std. VIII?	11	11
8	For satisfactory evaluation of the project, do you believe that the project should be continued next year in Standard VIII?	17	5
9	Do you think that the project should be implemented in Standard IX also?	12	10
10	Did you come across any difficulty from the Government?	-	22
11	Did you come across any difficulty from the guardians?	5	17

III. COMPARISON BETWEEN TRADITIONAL AND PROJECT APPROACHES :

Sr. No.		Frequency	
		Yes	No
Do you think that in comparison with the traditional approach, the project approach is -			
1	better for fostering the principles?	16	6
2	easier for teaching?	8	14
3	more interesting in teaching?	17	5
4	better for solving problem?	19	3
5	better in understanding concepts of multiplication and addition?	15	7
6	more useful in developing an interest in students in learning mathematics?	18	4
III. COMPARISON BETWEEN TRADITIONAL AND PROJECT APPROACHES :			
7	better for making students to solve problems independently?	20	2

Sr. No.		Frequency	
		Yes	No

IV. STRONG POINTS OF THE PROJECT :

Do you think that in comparison with the traditional approach, the project			
(1)	Very good practical illustrations are provided in the text book.		
(2)	The students can learn independently.		
(3)	The basic principles are grasped very well by the students.		
(4)	Sufficient drill work on the principles is provided.		
(5)	Because the material is new, the teachers and students take interest.		
Contd...			

- (6) It becomes easy as there are no subtraction and division.
- (7) The students can solve the problems.
- (8) The method of solving equations is very good.
- (9) After getting clear idea of subtraction, negative numbers and additive inverse, it becomes very easy to deal with other aspects.
- (10) Number line is very useful in teaching inequalities between numbers.

V. SHORTCOMINGS OF THE PROJECT :

- (1) Answers are not given in the text-book.
- (2) Two periods are not sufficient.
- (3) Very small numbers of examples are given in the text-book.
- (4) The text-book is not appropriate for the present syllabus.
- (5) The difficulty level of the material in the exercises is lower than the ability level of the pupils.
- (6) Long multiplications are not included.
- (7) In some of the topics more time is required and hence the students lose patience.
- (8) It becomes difficult when the teacher concerned is on leave.
- (9) If the students remain absent even for one period he is not able to keep pace with the class.
- (10) Parents do not cooperate in the implementation of the project.
- (11) It is not continued in standard IX.
- (12) Teachers are not oriented sufficiently.
- (13) The project was started little late.

- (14) Private tutors teach the new matter with the traditional approach.
- (15) The students remain behind in the standard IX.
- (16) It becomes difficult for the teacher to change from traditional approach on to the new approach.
- (17) Long term orientation course was not organised and the short ones do only patch work.
- (18) Annual examination being the same, the students remain absent-minded in the class.
- (19) The achievement level of project students seems to be lower than that of non-project students.

C. RESPONSES OF THE HEADMASTERS

I

Sr. No.	Questions	Frequency	
		Yes	No
1	Was the teacher concerned willing to conduct this project?	12	-
2	Was the project continued for the whole year?	12	-
3	Were the students happy after participating in the project?	10	2
4	Do you believe that the project should be continued in the next year?	7	5
5	Would you participate if the project is continued?	7	5
6	Was the teaching in the project satisfactory?	11	1
7	Do you believe that the project is useful in improving education?	10	2

Seven head-masters were in favour of continuing the project while five were hesitant to continue. This is a point for serious consideration. This means that more than 40% of headmasters are not happy about some aspects of the project. These headmasters may be interviewed before any further follow-up programme is taken.

II

It is reported by the headmasters that on the average 66% of the students were happy, 23% of the students were unhappy and the remaining 11% of them were neutral about the project.

III

SOME REACTIONS OF THE HEADMASTERS :

- (1) Student is able to comprehend the principle but forgets it.
- (2) Concepts are fostered well by this project.
- (3) More periods are required.
- (4) Students are curious about the project.
- (5) The project being new, it is difficult to create an appropriate atmosphere and hence it is not possible to get a desired success.
- (6) The students are weak and hence results are not hopeful.
- (7) Specially trained teachers are required.
- (8) The project should be continued, if and only if it is possible to run the project in all the three standards, VIII, IX and X.
- (9) Addition and multiplications are easily mastered by the traditional approach.
- (10) The students get confused as they come across four operations in arithmetic while they come across only two operations in Algebra.

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- (11) Positive and negative numbers can be taught very well.
- (12) Problems and equations could be taught very well.
- (13) It is not possible to consolidate the principle learnt.
- (14) The parents have some doubt in the project and hence the students have less faith in the project.
- (15) The teachers engaged in private tuitions do not know this method and hence they discourage the students.
- (16) It becomes difficult when the teacher teaching in the project class is changed.

IV

SUGGESTIONS MADE BY THE HEAD-MASTERS :

- (1) More schools should be informed of the results of the project.
- (2) It would be better if more schools participate in the project.
- (3) It would be fruitful if the results of the experimental project are used in future.
- (4) The experiences of the project should be reflected in the new curriculum.
- (5) The project should be continued in at least two classes in a school.
- (6) The teacher should be continuously guided.
- (7) Demonstration lessons should be organised.
- (8) One question paper should be set at some convenient time for all the project students.
- (9) Teachers should be trained in the month of May.
- (10) Three periods should be allotted to the teaching of Algebra.

- (11) More examples on addition and subtraction should be given.
- (12) The text-book should be improved in terms of subject matter.
- (13) More orientation courses for the teachers should be organised.
- (14) If the text-book for standard IX is available, it should be given to the teacher for getting a broader view.
- (15) Homogeneous class formation is necessary.
- (16) The class should be selected in the month of June.
- (17) Every month a meeting of the teachers should be called.

V

SOME REACTIONS OF THE GUARDIANS :

- (1) Matter of the text-book was of lower calibre.
- (2) Assignments are not sufficient.
- (3) Guardians are not able to help their wards.
- (4) The project student is weak in Algebra.
- (5) It is doubtful whether a student can adopt the old method in future.
- (6) Answers are not given at the back of the book.
- (7) I do not want my child to be taught this type of Algebra.
- (8) Teach the old matter, we also studied the old one.
- (9) The paper of annual examination is based on traditional approach and hence the student is not able to fare well.
- (10) Examples are too much difficult.

7 FOLLOW-UP PROGRAMME :

As indicated earlier, the project had its own limitations. The material was developed within the limits of the existing syllabus of Algebra for standard VIII and was implemented only during the regular periods allotted in the schools for the teaching of Algebra. However, the project implemented during the period 1964-65 to 1967-68 has fulfilled its own objectives. In particular, it has proved that the basic abstract notions of the new Mathematics can be grasped by the school-age children. The reactions of the participating teachers are also very encouraging. Having satisfied with the results of the project and the tasks being completed, the project has been now discontinued.

Based on the results of this four-year project of the teaching of Algebra in standard VIII, the Community Science Centre is now developing on the same lines two separate courses, one in Algebra and the other in Geometry for standards VIII, IX and X. In developing this course, the group has kept before them the new Mathematics curricula developed in USA and UK, viz., the School Mathematics Study Group in the States and the School Mathematics Project in U.K. The Community Science Centre is also planning to develop the necessary text material which will be used for trials in the academic year 1969-70.

APPENDIX I

1963-64 DISCUSSION GROUP FOR THE ALGEBRA TEXT

1	Shri G.A. Dalal	Sheth C.N. Vidyalaya	Ahmedabad
2	Dr. K.G. Desai	A.G. Teachers' College	"
3	Shri P.A. Gadkari	V.S. Trivedi Tutorial High School	"
4	" V.M. Joshi	Asarwa Vidyalaya	"
5	Prof. C.M. Mehta	A.G. Teachers' College	"
6	Shri H.M. Mehta	Swastik High School	"
7	Prof. N.K. Mehta	L.D. Arts College	"
8	Shri P.P. Mungali	Shreyas Higher Secondary School	"
9	" R.J. Patel	Sheth C.N. Vidyalaya	"
10	" C.C. Shah	-do-	"
11	Miss D.A. Shah	Jivkor Vanita Vishram Mahlia Vidyalaya	"
12	Shri G.T. Shah	-do-	"
13	Dr. K.B. Shah	Physical Research Laboratory	"
14	Shri M.J. Shah	Bharati Vidyalaya	"
15	" P.C. Shah	Fellowship High School	"
16	" H.M. Shukla	Unnati Vidyalaya	"
17	" S.A. Shukla	Navjivan High School	"
18	" D.N. Thaker	A.G. High School	"
19	Dr. P.C. Vaidya	Department of Mathematics University School of Sciences	"

APPENDIX II

SUBJECT MATTER PRESENTED IN THE ALGEBRA TEXT

- Ch. 1 - Set and sub-set, finite and infinite set, null set.
- Ch. 2 - Number-line and negative numbers.
- Ch. 3 - Unknown numbers and true set.
- Ch. 4 - Additions, addition as a binary process, commutative and associative laws, additive inverse.
- Ch. 5 - Multiplication, commutative, associative and distributive properties, multiplicative inverse.
- Ch. 6 - Problems and equations.
- Ch. 7 - Expansions.
- Ch. 8 - Simplifications.
- Ch. 9 - Substitution of values.
- Ch. 10 - Graphs of simple algebraic relations.

In the first edition of the text, answers of the problems in the text were not given. This point was discussed and the participating teachers advocated the need of answers to some problems. Accordingly, in the later editions, answers to odd-number problems in all the exercises were given.

APPENDIX III

SUBJECT MATTER OF THE TEACHERS' GUIDE

- Ch. 1 - History of the number system, natural numbers, binary system, commutative associative and distributive principles, sets and sub-sets, details and hints on finite, infinite and null sets, sets in Geometry, comparison of two sets, set definition of natural numbers.
- Ch. 2 - Negative numbers and number-lines, order relations, practical examples of negative numbers, additive inverse, rational and irrational numbers.
- Ch. 3 - Incomplete sentences, unknown algebraic numbers, true or solution set.
- Ch. 4 - Addition as a process, addition and number-line, vertical and horizontal additions.
- Ch. 5 - What is multiplication?, multiplication by zero, multiplicative inverse, multiplication of two negative numbers, rational number field, base and power.
- Ch. 6 - Algebraic problems, equations, solution set, solution of equations.
- Ch. 7 - Expansions.
- Ch. 8 - Simplification.
- Ch. 9 - Substitution, numerical values.
- Ch. 10 - Structure and relations, tables, graphs and formulae, graphs of solution sets.

In addition to these, the following were also included :-

- (1) Answers to the even number problems in all the exercises in the text,
- (2) Planning of the annual work, specimen unit planning,
- (3) Blue print for a unit test,
- (4) Some objective test papers.

