CHAPTER ONE
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1.1. SCOPE OF MATHEMATICS

The nature of mathematics, in terms of abstractions, generality, structures and patterns, categoricalness, consistency, and independence led many a people to believe that the entire world phenomena can be interpreted mathematically. According to Kline (1953), Kepler identified the reality of the world with its mathematical relations, and Galileo thought that God wrote the world in alphabets of mathematical principles. He further made it possible to explain the various areas of human thinking and action as mathematical derivatives. For instance, painting and perspective, science born of art, the quantitative approach to nature, the deduction of universal laws, grasping the fleeting instant, the Newtonian influence on literature and aesthetics, mastery of ether waves, mathematical theory of ignorance, prediction and probability, the statistical view of nature, the paradoxes of the infinite, new worlds through new geometrics, and the culmination of mathematics into theory of relativity have all been related to mathematics by him.

The dimensions of mathematics have been extended and enlarged on account of practical, scientific, aesthetic and philosophical interests of man. Volumes can be made available in libraries on subjects like: Mathematics of
population and Food; Mathematics of War and Foreign Politics; Mathematics of Radio, Television, and Electronics; Practical Mathematics; Applied Industrial Mathematics; Mathematical Physics; Technical Mathematics, Mathematics for Every Day Use and so on, which indicates the trend of thinking oriented towards finding mathematical explanations for different problems emanating out of variegated human needs and experiences. Kramer (1955) glorifies the importance of mathematics (with its ramifications into every conceivable area of thought) by its comparison with a tree, the exploration of whose branches takes most of the time and every time a new branch is explored, one has to come to the trunk, i.e., fall back for support on mathematical knowledge. It is considered to be the universal tool which helps mankind in building up civilizations, in interpreting physical and biological sciences, and in bringing out the advantages of science and technology within the reach of the common man. Hogben (1951) believes that calculating prodigy can be the only friend of man to defend himself from the economic tyranny of the modern times.

Lovers of mathematics can find aesthetic satisfaction of the highest order by completely involving themselves in the pursuit of knowledge and by making use of creative imagination and intuition in solving the mysteries of
nature. Bertrand Russell (1919), the master of abstract mathematical thought, finds austere, yet sublimely pure and perfect beauty in the subject. It is the romance with the subject that keeps the great mathematicians busy with working out clues for discoveries and inventions and not the vast implications and applications that their works may inherit. Einstein, while working for his 'Theory of Relativity' was perhaps never aware of the tremendous impact that his theory could have on the scientific thinking of the twentieth century. It seems that it is always the intrinsic satisfaction which makes a mathematician work round the clock and not the extraneous temptations.

Noted philosophers of the eminence of Whitehead and Bertrand Russell (1962) attach a great importance to mathematics for philosophical thinking because its symbolism adapted to the processes of deduction aids in building up intuitions in too abstract regions and thus helps in presenting the total picture of the whole propositions to be represented to the eye sight. It works as a convenient mode of writing and proves effective for simplifying the complex ideas.

The frontiers of knowledge are mostly determined by the quality of education (formal and technical) and the success of education in various disciplines depends upon the degree to which they penetrate into the domain of mathematics. It not only helps in building up the
understanding of various disciplines, but also accelerates research on scientific designs.

The educationists are prone to believe that study of mathematics, in itself, helps in mental and intellectual development and disciplines the human behaviour indirectly and probably unconsciously by providing training for simplicity, accuracy, certainty and verification of results, originality and reasoning.

If the knowledge of mathematics influences the life of man in all aspects and helps mankind in the creation of its history and if the civilizations can be traced from the Greek period down to this day synchronising the course of mathematical developments then the Education Commission's (1966) observations:

"...the advent of automation and cybernetics in this country marks the beginning of the new scientific-industrial revolution and makes it all the more imperative to devote special attention to the study of mathematics. Proper foundations in the knowledge of the subject should be laid at school, ....." need thoughtful consideration.

1.2. PLACE OF MATHEMATICS IN SCHOOL CURRICULUM AND APPROACH TOWARDS ITS TEACHING IN INDIA

Mathematics enjoys a unique privilege in the school curriculum in almost all the countries of the world. In the past it was included from the disciplinary point of view for the training of mind and to reason about
The theory of mental discipline and faculty psychology have, however, no appeal for the modern educator but mathematics has elevated itself very high due to its use and applications to life. The utilitarian aspect of mathematics would emphasize understanding and concept learning much more than the formal doctrine would do, because in the latter, the idea of teaching mathematics is to train the faculties of mind and so naturally there was plenty of stress on mechanical work and drilling of computational processes. Since the utilitarian aspect would involve application of learnt principles to practical situations, understanding occupies an important position and concept learning becomes of prime concern. In the modern world of science and technology there is a need to train for understanding and skill both.

Advances in psychology, recognition of individual differences, changing socio-economic and political conditions, scientific and technological advancements, improved techniques of teaching, curriculum development and evaluation are some of the significant factors which have contributed to the revision of mathematics courses time and again.

Inspite of such advancements, the situation in India remains static and unchanged for the past fifty years. The Secondary Education Commission (1953) recommended compulsory teaching of mathematics upto junior secondary stage and for another two years as a core subject at the higher
secondary stage. In the last year of the higher secondary classes advanced mathematics becomes an optional subject with the 'Humanities' and 'Sciences' groups. In the 'Technical Group' it is introduced as 'applied mathematics' while with the 'Home Science Group' it acquires the status of elementary mathematics. In the first ten years of schooling the subject is taught as arithmetic up to the primary stage and at the subsequent stages algebra and geometry are included with arithmetic. The mathematics curriculum in schools in India is the traditional one with compartmentalized branches being introduced at various stages. The syllabuses are arbitrarily framed without taking note of the individual or social needs as if no significant changes have taken place in the country and in the world. Curricular practices are based on a body of mechanical manipulations and routines and there is too much emphasis on the subject-matter. Fraser's (1962) remark that "for the most part, the sequence of topics and their grade placement was determined by tradition rather than by efforts to discover what could be learned most effectively by children at various age-levels", holds true in Indian conditions of schooling.

Teaching methods, generally based on lectures and drill-theory aim at imparting the 'dead-material' to the pupils without offering them opportunities to sharpen
their intellect and form 'insights' and 'concepts' of the numerous mathematical computations. The teacher seldom thinks of the possibilities of making use of mathematics-laboratories. Whitehead's (1956) notions that mathematics, "thought in the sphere of abstractions from any particular instance of what it is talking about", seems to have universality of application. Bad teaching results into the fear and hatred for mathematics which in complete agreement with Sawyer (1962) "is a tradition handed down from days when the majority of the teachers knew little about human nature, and nothing at all about the nature of mathematics itself." Krug's (1960) comment that "mathematics is to many people an emotional blind spot. They have learned to hate and fear mathematical symbols, expressions and activities," though made in an altogether different setting, has identical appeal to the Indian system of education.

Teacher preparation, like other fields of education is inadequate. The theoretical background which the prospective teachers build up in the training institutions has no bearing on school teaching. Progressive teachers, if any, are discouraged by the traditionalists.

The tale of text books is equally discouraging, even though, in some States of India, they are nationalized.

It would not be exaggerating to remark that the approach to teaching of mathematics in India is in complete
disregard to psychological principles of learning, motivation, mental and physical development and individual differences and is unconcerned with essential characteristics of all intelligent and emotional perception.

Such a demoralising approach towards the teaching of mathematics has certainly hampered the progress and therefore, there is a tremendous necessity to vitalize the mathematics programme in schools so as to meet the perpetually increasing demands and mathematical needs of our society and the world of tomorrow.

1.3. VITALISING THE SCHOOL MATHEMATICAL PROGRAMME

The shortage of mathematicians was felt during the world war II and the reason for it was attributed by Baberman (1964) to "the failure of the traditional school mathematics offerings to interest young people in the subject, or indeed, to acquaint them with more than its computational aspects." When America experienced the early setbacks in the space-race, her attention was focussed towards bringing about improvement in the teaching of school-mathematics. The need of the hour is the effective communication of mathematical knowledge, which can be ensured only when the language of mathematics is carefully, purposefully, and ingenuously designed keeping in view the explosion of mathematical knowledge and its penetration into the most diverse branches of learning and technology. For the effective communication of mathematical knowledge,
the subject should be treated as a phenomenon of human action and human mind, and should be dealt with delicately and precisely.

The clues for vitalizing the mathematics programme can be made available by critically analysing and evaluating:
(a) the objectives of teaching; (b) curriculum developments; 
(c) learning and teaching theories; and (d) evaluating the end products of instruction.

1.3.1. OBJECTIVES OF TEACHING MATHEMATICS IN SCHOOLS

It would be appropriate to summarily narrate the existing conditions of educational demands in India before coming to the formulation of objectives of teaching mathematics. India is faced with problems typical of the developing countries. A great rush in the educational institutions has been a significant feature on the educational scene of the country since Independence (1947).
The enrolment (Education in India, Ministry of Education, Government of India annual Publications) of students has increased from 15 million in 1947-48 to 70 million in 1965-66. The number of children which was 22.27 million in 1950-51 in the elementary schools rose to 61.90 million by 1965-66. The number of pupils during the same period in the higher secondary classes (IX - XI) increased from 1.22 million to 5.51 million. It is expected that still greater rush at the middle and higher secondary school levels would continue throughout the rest of the twentieth century due
to the introduction of free and compulsory primary education. On the one hand, there is explosion of population and on the other hand, explosion of knowledge. In this context therefore, there is need to seek a legitimate balance between the quantity and quality of education and it would be the goal of educational thinkers, planners and policy-makers to ensure that the efforts of the country do not go waste by spending huge funds on the teaching of that 'inert' material, which has no significance and utility in the modern world.

Education Commission (1966) observes that if education has to be treated as a powerful tool of modernity, if India has to acquire self-sufficiency in food, ensure economic growth and full employment, seek for social and national integration, develop its political stability, then science will have to be made as a basic component of education and culture. It implies strengthening the mathematics programme so as to work hand in hand with the recent trends in the contemporary world of scientific thinking.

In view of the discussion submitted in the preceding paragraph, the objectives of teaching mathematics seem to have fallen in line with the observations made in the Report of the Seminar on the Teaching of Mathematics in Secondary Schools (1958) which are as follows:

1. To enable the pupils to learn the techniques of problem solving.

2. To develop functional thinking in them.
3. To develop skill in the use of mathematical language in understanding the world about them.

4. To develop mathematical skills, understandings (conceptual) and attitudes necessary to solve the quantitative problems faced by them in their immediate and anticipated environments. These objectives promise their contribution to the general aims of education, namely, developing democratic citizenship, improving vocational efficiency, developing personality, and educating for leadership as put forward by the Secondary Education Commission (1953) and also observed by the Education Commission (1966).

The objectives of teaching mathematics lead us to conclude that the mathematical programme should concentrate on developing conceptual understanding involved in the mathematical principles and operations. It provides clues for curriculum improvements simultaneously.

1.3.2. CURRICULUM DEVELOPMENT

The school curriculum is in a state of flux not only in India but also in most of the advanced countries of the world where the traditional curriculum was long back transformed under the impact of progressive education. The forces accelerating the pace of shift in the curriculum practices, according to Breslow & others (1960) are: special interest groups; social and technological forces; foreign educational
practices; scientists' influence, educational impact of alienation of youth from the general culture shifts in values, changes in family and group life; mass media and automatic teaching and social and psychological research trends. UNESCO's publication (1962) on world trends in Secondary Education reveals that the trends in the secondary school curriculum are mainly governed by (i) the modern scientific and technological achievements; and (ii) need for a democratic human society. Fraser (1962) writes that in the U.S.A. many universities and study groups are busy in remodelling the mathematics courses. Mention of thirteen such projects was made, which laid emphasis on concepts for organising the curriculum. Mendenhall, et al. (1960) and Julien Roberts (1966) reviewing the research on curriculum trends pointed out need for increased emphasis on concepts rather than mere computations of mathematical problems. The various trends in the development of mathematics curriculum and the objectives of teaching the subject as cited earlier force on us the task of revising the old curricula and plan a new mathematics curriculum by
establishing a sequence of learning experiences in appropriate contexts in order to enable the pupils to acquire quantitative understandings and knowledge of specific mathematical tasks and skills. The new programme of mathematics, therefore, must include those theories and the content which have grown very important in the sciences because India may demand greater number of technicians for the promotion of rapid industrialization.

It is difficult to locate significant research trends in connection with mathematics curriculum in India as most of the work is in the form of M.Ed. Dissertations, which is highly disorganized. The National Council of Educational Research and Training has recently begun working on new syllabuses (1967) of mathematics for junior secondary classes, the effectiveness of which still needs evaluation for successful implementation. Moreover, the courses are arbitrarily chosen without looking into the capacities of students. One project under the joint auspices of N.I.E. and H.E.W. on curriculum and teaching of mathematics has already been completed (1963-65). It aimed at revising the old syllabuses and improving the quality of teaching mathematics.

1.3.3. LEARNING AND TEACHING THEORIES

Psychological theories including learning have significant appeal to teaching practices. Gage (1964) suggests need for transforming learning theories into
teaching theories. Bruner (1964) says a theory of instruction seeks to take account of the fact that a curriculum reflects not only the nature of knowledge itself but also the nature of knower and the knowledge-getting process. Learning theories according to Hilgard (1958) chiefly fall into two major categories, namely, (a) Stimulus-response theories due to Thorndike, Guthrie, Skinner and Hull, and (b) cognitive theories advanced by Tolman, Gestalt psychologists and Lewin. Besides, theories of psychodynamics and Functionalism have contributed to the development of learning theories. All these theories were evaluated on the basis of six major problems: (a) capacity; (b) practice; (c) motivation; (d) understanding; (e) transfer; and (f) forgetting.

Stimulus-response theories suggest preliminary type of learning which involves sensory-motor type of intelligence, while the later theories (cognitive) mainly speak of insightful learning involving reflective intelligence. For mathematics teaching both of them will have to be taken side by side. For mechanical computations the first set of theories may be used as basis but for the conceptual understanding later theories are more useful.

It follows that the learning theories may be utilized by the teacher of mathematics for his own advantage and to the advantage of students. It would not be possible to treat these theories in great details here but the inferences can
be drawn out of them to be used as the directive principles for teaching.

The learning principles appropriate to teaching of mathematics, which are broadly in agreement with those cited by Fehr (1953) and Dutton (1964), may be summed up as follows:

1. Individual differences exist in learning activities which are determined by maturation, empirical constants and other constants appearing in the behavioural laws.

2. More intelligent person forms better structures than the less intelligent person.

3. Practice with meaning is an important factor in developing and building cognitive structures. The frequency of practice is determined by the complexity of the task.

4. Learning is developmental with time as one of its dimensions.

5. Learning takes place when there is a satisfying condition of reward and need-fulfilment.

6. Goals facilitate learning. Ego-involvement, levels of aspiration, anxiety, and ego-threats help in motivating the learner.

7. Transfer takes place in learning situations involving identical elements of insight. Conceptual learning is easy for transfer. Interference with new learning upsets old structures.
8. Motivated forgetting amounting to unconditioning of incorrect (S-R) bonds helps in building up correct bonds.

9. Understanding depends basically on habit but for higher learning it depends on meaningful structures and generalizations. According to Bruner (1964) the mode of representation, its economy and effective power structuring knowledge and understanding, however, vary at different ages to different styles among learners.

The above treatment suggests that the teaching of mathematics should strive at building up structures, developing insights and concepts among learners instead of wasting all time on mechanical computations. The basis for teaching should be Hilgard's six problems: capacity; practice; motivation; transfer; forgetting and understanding.

1.3.4. EVALUATING THE END PRODUCTS OF INSTRUCTION

The central problem of all educational efforts is learning. It is the process of directing human behaviour in ways satisfying to the individual as well as to the society. An organised system of evaluation facilitates learning by testing accomplishments, diagnosing difficulties and predicting student success in the subject.

An effective evaluation programme permits a wide variety and range of curricular materials and aims at evaluating understanding rather than mere recall type information. The end products of instruction, if carefully
and properly evaluated, would help immensely in re-modelling and re-organising the curricular practices, improving instructional material and methods of teaching and also in counselling students.

In India, the various commissions, such as the University Education Commission (1949), the Secondary Education Commission (1953), and the Education Commission (1966) have all spoken vehemently against the system of examinations in our country. Predominantly, essay type of examinations are in vogue, which measure only the inert material memorized in the form of information. Examinations are external and taken once in a year. In this way it becomes difficult to evaluate the real understanding of the subject. There is a tremendous need to improve the system of examinations in the country.

Gibb and others (1960) opine that the basic principles of test construction in mathematics require that test-items be designed to measure understanding of a principle or the ability to apply it, to appraise different levels of achievement and to test the 'why' as well as the 'how.' They have based their observation on the comments by Meder and Edwin and also on the basis of 18th and 22nd year books of National Council of Teachers of Mathematics. In recent years there seems to be a trend of evaluating understandings in relation to curriculum though only in a limited way and much less on the 'algebraic concepts,' so there is a need to explore this aspect also.
To summarize the discussion advanced in the preceding pages of this chapter, it may be concluded that the significance and status that mathematics enjoys in the modern world and the vast implications that it has for the extension and enrichment of civilizations and cultures, make a compelling demand on the teachers to lay a strong foundation of mathematics right at the initial stages of schooling by developing new curriculum, preparing the teacher for subject competence, enabling him to get acquainted with psychological principles of learning and teaching, and lest but not the least, helping him evolve a sound system of evaluation.

Recent trends in curriculum development and evaluation procedure are thus favouring the teaching for 'the development of concepts' rather than for 'simple manipulations'.

1.4. MATHEMATICAL KNOWLEDGE AND CONCEPTS

Understanding of mathematics involves the following:

1. Mastery over computational processes and necessary skills.
2. Conceptual understanding of the subject.
3. Applications of mathematics in different situations.
4. Appreciation of mathematical ideas.

Unfortunate part of the teaching of mathematics is the emphasis laid down on the successful drilling of various mechanical computations which, according to Piaget (1961), involves merely sensory-motor intelligence.
He refers to a situation when a child knows to count a set of objects without actually understanding the concept of number. Similar situations are observed among pupils where they know mechanical manipulation of certain mathematical problems without having any understanding of concepts. Mathematical knowledge, therefore, involves the mastery of both skills and concepts, thereby ensuring greater application and appreciation of mathematical ideas.

1.4.1. CONCEPTS

Learning is a developmental process involving change in behaviour from perceptual-motor skills to the formation of concepts. Russell writes in the Encyclopedia of Educational Research (1960) that "concepts are learnings that permeate thinking", and they are marked by "consistency of differential, generalized, symbolic response". "Conceptualizing makes possible rational behaviour - exploring, ordering, solving, creating, and predicting. In a narrower sense, perhaps, the clarity and completeness of a child's concepts are two of the best predictors of his success in most school learnings" (ibid, p.323). Vygotsky (1962) takes a concept "as an active part of the intellectual process, constantly engaged in serving communications, understanding and problem-solving". He further points out that a concept is not an isolated and changeless formation but it is formed through "the interplay of associations in which all the elementary mental functions participate in a specific combination".
The systematization of working leads to concept-formation. Piaget (cited by Flavell, 1963) accounts for concept formation as a 'changeover from sensory-motor intelligence to reflective intelligence' involving formulation of hypothesis or hypotheses, collection of data, analysis of data and verification of results. According to Flavell (1963) assimilation and accommodation give rise during sensory-motor development to an increasingly elaborate and complex organizations. Assimilation works in building up specific cognitive structures, which are 'mobile frames' and may be successively applied to various contents explaining the 'accomodating schemas'. Russell (Encyclopedia of Educational Research 1960, p. 325) on the basis of numerous studies concludes that the nature of the problem presented, the goal of the learner, the personality of the learner, chronological age, mental age, intelligence of the learner, the materials used as examples, the manner and order of presentation, the nature of the validation, and the use of the concept help in building up the conceptual understandings. They are supported by the learning theories as well, as explained earlier under caption 1.3.3.

1.4.2. MATHEMATICAL CONCEPTS IN SCHOOL CURRICULUM

Mathematical concepts are related to the concepts involved in the mathematical operations. At the school stage they may be classed as arithmetical concepts, geometric
concepts, and algebraic concepts. Present thinking on mathematical concepts seems to have attained the top priority consequent upon the classical works on concept developments by Piaget and his associates (1948, 53, 56, 61, 64) for improving the mathematics programme in schools.

Evidence was given by Skemp (1961) to the fact that repeated sensory-motor experiences affect the development of arithmetical concepts. The development of mathematical concepts takes place in the same fashion as in the case of 'general concepts' in any learning activity. It is a slow process. Careful organization and integration of sensory-motor experiences helps in the development of concepts.

The development of concepts is basic to growth in learning capacity. Engen (1953) lists the following important implications concerning the development of concepts for the teaching of mathematics:

1. Concept development is earlier in intelligent persons than in averages or below averages.

2. Conceptual development is a growth process. The teacher should not expect pupil to develop a mature concept in a few days. The works of Piaget and his associates give evidence to this fact (1948, 1953, 1956, 1961, 1964).

3. Concepts cannot be established by definitions unless the pupil has matured to grasp the basic elements in process or sensory-motor experiences. It implies that there
are stages in the pupil's development which are characteristic of particular growth of conceptual understandings. Flavell (1963) presenting commentary on Piaget's works says of various stages of development. A stage, according to him, is an initial period of preparation and a final period of achievement. In the preparation period, the structures which define the stage are in process of formation and organization. The preparatory period gives way to a later period in which the structure in question forms an organized and stable whole. He refers to horizontal and vertical decalages. In the former repetitions take place in the single period of development, while in the latter the repetitions occur at a different level of functioning rather than within the same level. Piaget takes for granted the fact that considerable continuity lies behind or beneath the sequence of stages elaborated by the developmental theorists.

These principles have important implications for the teaching of mathematics in schools. It would be worthwhile to include only that content in the syllabus the concepts of which have a definite relationship with the particular stage of the pupil's development and the ultimate objective should be the conceptual understanding of mathematical processes rather than simple drilling of computations.
1.5. PRESENT INVESTIGATION

The problem, in hand, emerges out of the discussion carried on earlier into the realm of 'conceptual understandings' as supported by recent trends in curriculum principles, learning theories and evaluation procedures and strives at developing a technique for evaluating the understanding of 'algebraic concepts' in pupils at the Junior Secondary Stage in the Punjab, Haryana and Union Territory of Chandigarh, with implications for modifying and improving the syllabuses and helping teachers to evaluate their own method of teaching algebra, and counsellors in providing proper guidance to the pupil.

The choice of algebraic concepts at junior secondary stage had a special appeal primarily because it is introduced at this stage only, which forms an important branch of mathematical studies even at later stages and its teaching is in miserable condition; and secondly, because not much work of this nature on the subject could come to the notice of the investigator even in the world literature, that could be made available here. The various Mental Measurements Year Books make a mention of the following tests on algebra:

1. Orleans Algebra Prognosis Test (Fourth Mental Measurements Year Book); 2. Diagnostic Test in Basic Algebra and 3. Illinois Algebra Test (Fifth Mental Measurements Year Book); 4. The Seattle Algebra Test, 5. Survey Test of Algebraic Aptitude, and 6. Votaw Algebra Test (Sixth Mental
Measurements Year Book). In India an attempt was made to conduct an all India Survey to find out the mathematics achievement. These references, however, fail to give any indication as to the preparation of algebraic concepts test pertinent to the syllabuses. Beagle (1968) points out that psychologists can provide very few useful answers to our questions about concept growth, and there is a need to build up a theory of mathematical concepts, and such a theory will be quantitative rather than qualitative. He is of the opinion that there is a necessity of constructing instruments which measure how well a student understands a particular concept.

1.6. ALGEBRAIC CONCEPTS AT THE JUNIOR SECONDARY STAGE

Algebra concerns the arithmetical operations in general and seeks to find out common properties in operations of a particular kind. It aims at establishing concepts of new classes of numbers.

Algebra is introduced at the junior secondary stage with a view to enable pupils to (i) understand symbolic representation and arrive at generalization; (ii) translate a verbal problem into a system of equations; (iii) establish relationships in different structural forms; and (iv) interpret and understand graphs.

There are traditional syllabuses and nationalized test books on algebra in the Punjab, Haryana and Chandigarh. The syllabuses include problems on symbolic representation,
use of formulas, directed quantities, brackets (parentheses), laws of indices, simple identities, simple equations, factorization and graphs.

The concepts in relation to the following algebraic processes, methods and laws seem to have been mastered by the Junior Secondary pupils as a result of schooling:

1. Generalized numbers concerning the symbolic representation of arithmetical numbers in terms of algebraic entities.

2. Directed numbers attaching algebraic values to quantities indicating amount as well as direction.

3. Equations with one or more unknown quantities.

4. Brackets (parentheses) involving their conventional uses for the purposes of grouping.

5. Substitution involving transformation of an algebraic entity into concrete numerical value by assigning numerical value to each one of the symbols in formulas or equations.

6. Exponents or the Laws of indices in relation to algebraic entities.

7. Graphs for pictorial representation of verbal problems, relationships & formulas.

The syllabuses for various grades at the junior secondary stage in the Punjab, Haryana and Chandigarh make it clear that the above mentioned concepts should have been mastered by the pupils in different proportion and extent.
depending on the instructional programme at these grade- 
levels. Since algebraic knowledge has its basis in the 
mastery of fundamental concepts besides skills, so it was 
thought to undertake a status study in order to ascertain 
the real conceptual knowledge of pupils in algebra as a 
result of its teaching.

1.7. OBJECTIVES

1. To find out the development of algebraic 
concepts in pupils at each grade level at the junior 
secondary stage; the development of algebraic concepts 
to be evaluated in terms of the emergence of such concepts 
as may be related to algebra at various grade-levels for 
girls and boys, taken separately and collectively.

2. To find out the effect of levels of intelligence, 
namely, high, and low on the development of algebraic 
concepts in pupils at the same grade level; girls and boys 
to be treated separately as well as collectively.

3. To develop a test on algebraic concepts as no 
other instrument is available so as to ensure the assessment 
of the first two objectives.

4. To suggest measures for improving the teaching 
of algebra on the basis of development of concepts in 
pupils.

1.8. HYPOTHESES

The study was advanced on the basis of the 
following hypotheses:
1. The levels of instruction, varying according to the content (subject-matter) for each grade, are responsible for the variations in the understanding of algebraic concepts from one grade to another.

2. Sex-differences exist in relation to the development of algebraic concepts.

3. The development of algebraic concepts in pupils depends on their levels of intelligence, that is, superior intelligence accounts for better understanding of algebraic concepts.

1.9. SIGNIFICANCE OF THE STUDY

It is a complex problem to uncover a relationship between instruction and the development of algebraic concepts on the one hand and between maturity and the conceptual understanding on the other but the combined effect of these factors has undoubtedly a definite bearing on the understanding of concepts. It is an humble attempt to evaluate the status of the development of algebraic concepts in relation to existing curriculum practices in the Punjab, Haryana and Chandigarh with hopes of making the mathematics programme - old or new, a success in the country.

1.10. IN THIS WORK

The organization of chapters in the research report has been made with a view to ensuring the
'completeness' of the chapters. Conventional method of dealing with analysis and interpretation of data in different chapters, has been avoided because this approach fails to give the wholistic picture. Each type of analysis of data in this work is followed by the interpretation of results in the same chapter. Second chapter deals with procedure and techniques; third and fourth are devoted for developing the Algebraic concepts Test and its reliability and validity; fifth, sixth, seventh and eighth chapters give details of analyses of data along with interpretations; ninth chapter furnishes the overall discussions; and tenth chapter deals with the conclusions of the research. Bibliography and appendices are given at the end of the research report in the usual manner. All calculations in this work have been done by hand and there may be rounding difference in the second or third place of decimals even though all precautions were taken to eliminate such errors.