CHAPTER  ONE

INTRODUCTION
One of the most significant concerns of education has been imparting of instruction efficiently. In fact, education is concerned mainly with the process of teaching and learning. From the student's point of view, learning is even more important since it is not what the teacher accomplishes but what the student does that results in learning. In order to maximise learning, new efficient and effective techniques based on sound psychological principles and research will have to be devised. This requires, inter alia, that the process of teaching and learning should be made more explicit and precise and that the student should be made very active participant in the learning process. Fortunately as a result of long study and research, a new technology of instruction has emerged with some promise of success in this direction. It is a technique which is more concerned with refinement and definiteness of the process of teaching and learning. In the present day terminology, it is known as programmed instruction or programmed learning.

Most of the work on programmed instruction seeks to apply knowledge of the learning process. The empirical facts have been known for sometime, but only
recently have they been quite seriously applied to the
development of instructional devices and procedures. This
relationship to scientific understandings offers the
potential for teaching many subject matters much more
effectively than they are taught at the present time
(Taber et al., 1965). Many teachers may find programmed
instruction as liberating devices that allow for many
more individual differences than the lock-step instruction
now found in large classes, required text books, motion
pictures and television. With the employment of this
teachers can be freed from many mechanical tasks of paper
correction and the repetition of mountains of curriculum
details that must be covered. In addition, administrators
are able to provide better education at lower costs due to
savings in time, yet they still have objective assurances
of student achievement (Fry, 1963). It might be asserted
that in the Indian context, programmed instruction has
arrived at a most opportune time. We find that the demands
upon our educational and training system have outstripped
the available resources to meet them. Further, population
explosion has added new dimensions to this problem. There
is also a paucity of trained and efficient teachers.

Again the teacher can not be
entirely left alone to depend upon his own resources and
talents. He has to be provided with the fruits of modern
instructional technology. It is now widely recognised that programmed instruction can go a long way to help the existing teachers to meet their instructional challenges.

The antecedents of programmed instruction may be traced to the most ancient times. It has even been speculated that it has distant links with the Greek philosophers. Socratic dialogues, for instance, reflected the basic procedure of programmed instruction. He used to guide his followers to knowledge by conducting them conversationally along a from fact to fact, insight to insight. In our own times the method of tutorial education is very much close to programmed learning. This method has been perfected by the colleges of the great English Universities and in the U.S.A. in one form or the other. In the tutorial method things emphasised are:

- continuous exchange of questions and answers between the tutor and his student,
- the unfolding of information and explanations and the constant selection of new material on the basis of what has gone before (Pandey, 1970). However, it would be more appropriate to ascribe the origin of modern programmed instruction directly to behavioural psychology and to contemporary psychology of learning. Learning is indicated by a change of behaviour. Whether the change involves the acquisition of new response modes or the strengthening of behaviours pre-existing in the individual's
repertory, some behaviour must be strengthened. In experimenting with the process of learning, psychologists have used a variety of devices. These devices present a stimulus to elicit desired behaviour and when behaviour is omitted, it is followed by a consequence which tends to reinforce it. Likewise, in any teaching-learning situation, the teacher's job is to get the student to make the desired response to a given stimulus and to increase the probability of him making the same response each time this stimulus is presented to him. Similarly, the teaching machines may be explained in terms of the concepts of the stimulus-response theory which has been advocated by behaviouristic psychologists. However, programmed instruction in its present form originated in the U.S.A. due to the dynamic efforts of American psychologists of the present century. Edward L. Thorndike of the Columbia University is, best known for his 'law of effect'. This states that learning which is accompanied by satisfaction on the part of the student is likely to be more permanent than learning which is accompanied by frustration or dissatisfaction. The principle of rewards through success or satisfaction has come to be known as reinforcement. Next mention historically goes to Sidney Pressey of Ohio State University who is considered by some as 'doyen of teaching machines', for probably he was the first to introduce their use in the 1920s. He devised a machine which was essentially
meant for testing the students by means of multiple choice question. But later he claimed that his machine could teach as well since it did not present the next question until the correct key had been found. Further, the machine could also check up the number of mistakes committed by the student. As compared with modern advanced teaching machines, it was rather a crude method of teaching but Pressey was surely able to demonstrate that his system of telling a student immediately whether he was right or wrong, and making him continue until he was right, did produce measurable amounts of learning. Unfortunately, however, the time was not ripe for his proposals partly because of economic depression but mainly perhaps because he was ahead of his time. Pipe (1966), has observed that educators showed little interest in his ideas and he had to set them aside for a quarter of a century.

E.F. Skinner of Harvard University - the originator of linear programmes - has built up an international reputation for his research on operant conditioning. In early 1950s, Skinner, on the basis of his famous experiments in operant conditioning of pigeons demonstrated that human behaviour could also be shaped and controlled by 'successive approximations' and reinforcement schedules. Using the knowledge gained from his experiments, he set about developing a technique for presenting information to human learners based on sound psychological principles and developed the linear programme.
Programmed instruction has now gained a wide recognition. It has established its claim as an attempt to systematise education and training and also as an endeavour to make teacher a more efficient mediator between learning and the learner. Walter B. Koosenk (1963), has even gone to the extent of saying that the development of programmed instruction has been called the most significant educational achievement of the 1960's, if not one of the most revolutionary innovations in the entire history of education. In India, programmed instruction has now come to stay and reasonable amount of research is being conducted on its various aspects. It is to be hoped that in the near future, programmed instruction will prove as the most efficient tool to improve and refine class-room instruction.

CONCEPT OF PROGRAMMED INSTRUCTION

Although B.F. Skinner may not be the sole originator of programmed instruction, it is widely accepted that the real impetus to programming movement was given by him with the publication in 1954 of his article, "The Science of Learning and the Art of Teaching". His object was to treat class room learning like any other situation in which certain behaviour, in this case largely verbal behaviour, is to be shaped. The student must progress gradually from familiar to unfamiliar material, must be given an opportunity to learn the necessary discriminations and must be reinforced.
The term programmed instruction or programmed learning has been defined differently by various programmers sometimes broadly and other times more specifically. Cook (1961) takes a broader view of programmed learning when he defines it as a term sometimes used synonymously to refer to the broader concept of "auto-instructional methods". This auto-instructional method promotes the orderly and controlled development of an individual's skill in much the same way as a good tutor might do. By presenting lessons in small, carefully sequenced steps, complicated skills can be developed by gradually progressing from very simple to very complex levels of performance. Since the student must perform actively at each step during training, it is possible to carefully guide the development of his skill by means of immediate confirmation as to the correctness of each response. Furthermore, the auto-instructional technique facilitates the evaluation and improvement of the materials during the course of their development in that the difficulty level or contribution of each step can be carefully ascertained and, when necessary, any step may be modified or revised (Klaus, 1961).

James E. Espich and Bill Williams (1967), take a more specific view of programmed instruction when they define it as "a planned sequence of experiences, leading to proficiency, in terms of stimulus-response relationships that have been proven to be effective".
In this formulation, a programme is an educational device that will cause a student to progress through a series of experiences that the programmer feels will lead to the student's proficiency. The use of the term 'experience' indicates that the student must participate in the learning process. The phrase 'Planned Sequence' suggests that the person developing the programme has determined not only what experiences the student should have but also in what order they should occur. The term "stimulus-response relationships", refers to the basic behavioural science concepts on which the programmed instruction is based.

Finally, the expression "that has been proven to be effective", implies that the programme was subjected to actual tryout with the students and suitably revised till they are able to exhibit a predelineated proficiency when they have finished it.

Pipe (1966), has mentioned four characteristics of programmed instruction which may be briefly mentioned as under:

- **Small Steps**: The material to be learned is presented in what has been called 'optimally sized increments'.

- **Active Participation**: The student is continually made to interact with the programme since with each small step, a response is required of the student.

- **Immediate Knowledge of Results**: As soon as a student has made a response, he discovers whether he was right or wrong.
- **Self-paced**: Each student has his own copy of the programme. His rate of progress is determined by the speed at which he works his way through the programme; he is not forced to wait for those slower than himself nor is he left standing by those more apt.

To conclude this section it may be stated with Taber et al., (1965), that the programmed instruction is "a process of constructing sequences of instructional material in a way that maximises the rate and depth of learning, fosters understanding and ability to transfer knowledge to new situations, facilitates retention and enhances the motivation of the student. It is an explicit process, it is what an effective teacher does intuitively". As this process is studied, the expectation is that a practical teaching technology will come into existence in so far as the content in a specific area of study may be structured and properly developed according to definable rules.

**STEP-SIZE IN PROGRAMMED INSTRUCTIONAL TECHNOLOGY**

Step-size is an important property of a programme. A step is an increment in subject matter level to be learned with each succeeding item or frame in the programme, while the step-size indicates the amount of increase in subject matter difficulty with each step in the programme. A large step-size
could result in relatively few frames while a small step would indicate relatively large number of frames in the programme (Cook, 1961). In more simple terms, step may be defined as a unit of information while step-size denotes the amount of information given to the learner at any one time (Callender Patricia, 1969). In more specific terms step-size means the rate at which new concepts are introduced. A programme with large step-size, therefore, introduces new material at a higher rate than a programme with small step-size (Green, 1962).

Taber et al., (1965) quote Lumadaine (1960) to argue that nature of a step requires study because the meaning of 'step' and 'step-size' is, for most part, ambiguous. For example, a step may be defined in terms of the probability of a correct responding as one proceeds through a programmed progression. Step-size may also refer to the amount of material which the student must read before making a response or to the number of responses made before knowledge of performance is given to the student.

Fry (1963), likewise suggests that programmers are rather vague about the concept of step-size and that on the surface they make some bland statements to effect that the subject matter must be broken up into small bits that can be easily assimilated by the student. According to him following are some of the factors which could determine
step-size:

- **Length of Item in Words**: Perhaps one of the most objective measures of step-size is length. As a matter of fact, so-called "small step" programs do have fairly short terms in word length compared with other programs which do not claim to be 'small step'.

- **Length of Item in Working Time**: Another objective measure of small and large step-size is the amount of time it takes a student to respond. Programs which claim to be small-step do have somewhat higher responding rate.

- **Number of Responses**: The actual number of responses required of a student is another explicit criterion of step-size. Some items which require the student to make two or three responses certainly must be considered larger than the item requiring only one response.

- **Length of Response**: The length of a response can vary considerably from a single letter or number to a phrase or even paragraph. Surely, then, there is some rationale for stating that an item requiring the response of a single letter is a smaller step item than one requiring a lengthy phrase.
- **Idiational Content**: This is another factor involved in step-size. For example, if a student is asked to respond to a rote item like "The Spanish word for table is ....", he has a fairly simple response, but if he is asked to "Give a few key-words involved in the concept of justice ....", he might have considerably different task.

- **Repetition**: Yet another factor of step-size is that of repetition or "density of ideas". For example, Coulson and Silberman claimed to change Holland and Skinner's small-step programmes to a large-step programme by simply dropping about half of the items. Of course, most of the items dropped were those requiring repetition of an idea or perhaps re-statement of something already introduced. Thus the step-size can be increased by cutting repetition, or conversely by increasing the number of new concepts introduced in a given number of frames.

- **Probability of Errors**: Small-step programmes are usually those which have a very low error rate. Programmes which have a high error rate are not small step programmes. However, the difficulty is that error rate can be reduced by simply adding some cues and prompts.
BASIS OF STEP-SIZE FOR THE PRESENT STUDY

In the present study where the content relates to algebraic concepts, the factor dealing with the length of item in words was considered to be most practical and suitable. Other factors were found to be either not very practical or expedient.

OPERATIONAL DEFINITION OF STEP-SIZE

In the present investigation the number of words in a frame has served as operational definition of step-size. Small step-size consists of about twenty five words or less while the large step-size constitutes about thirty words or more.

The concern about the concept of step-size is based on the desire to increase the probability that a student responding to a given frame will make correct response. Skinner and others feel that the most effective programme is one which raises the level of the learner's proficiency to such small steps that the probability of the learner being wrong is so low as to be negligible. In fact, Skinner uses the percent correct as a measure of optimum size of the step. Further, the items which result in more than a minimum number of errors have always been viewed with suspicion by the Skinnerians. For example, More and Glaser (1958), quoted by Carr (January 1959), investigated the effect of size of step upon frequency
of errors and upon immediate and delayed retention. Using a single programme on elementary number theory, they varied the number of steps over four values: 30, 40, 51 and 67. Presumably, the greater the number of steps, the fewer the errors and the greater the retention. In this context many questions arise: Is it that the difficulty of the programme is directly related to the size of the step? Again is there no limit to decreasing the step-size and thereby increasing the number of steps?

The idea of step-size in programmed learning centres on methods of eliciting desired responses from students. In a linear style of programming a small step-size is favoured because it is assumed that presentation of material in small steps facilitates learning and minimises errors. But again, how big a 'small step' should be? This is an intriguing question which has always engaged the attention of research workers in the field of programmed instruction. In general, experiments comparing small step and large step programmes have demonstrated superior learning with small step programmes but only at the expense of added training time. Evans, Glaser and Homme (1959), quoted by Fry (1963), investigated the effect of step size in learning, using four groups, each with a different number of steps covering identical material. They found that small step programmes produced significantly better performance than large step sequences. However, there was a clear time differential between the two groups because small steps took longer time. Coulson and Silberman (1960)
obtained much the same results as Evans, Glaser and Humes, the small-step programme was significantly better as a learning device, although it took more time. These findings are further confirmed by Blank, et al., (1970). In a study by Blank, Douglas Machie and Fred C. Rankine (1970), it was found that the small step programme produced higher post-test scores, took more time to complete and had a lower error rate than the large step programmes.

It may be admitted, therefore, that not only is step-size a useful concept and the subject of interesting experimentation but it is quite conceivable that size of the step may interact with the first three levels of taxonomic categories of educational objectives in the cognitive domain as outlined by Dr. B.S. Bloom (1956).

TAXONOMIC CATEGORIES IN THE COGNITIVE DOMAIN AS A VARIABLE

For the purposes of this research, taxonomic category has been conceptualised as one of the variables. Further, out of the six categories in the cognitive domain, only first three namely, Knowledge, Comprehension and Application have been taken up for experimentation. It will not, thus, be out of place to take up a brief discussion of these three taxonomic categories.

KNOWLEDGE

Knowledge as defined here includes those behaviours and test situations which emphasise the remembering, either by recognition or recall, of ideas,
material or phenomena (Bloom, 1956). This class, therefore, involves the recall of specifics and generalisations; of methods and processes; and of pattern, structure, or setting. Recall simply means bringing the appropriate material to mind, usually without alteration. The knowledge objectives emphasise most of the psychological processes of remembering. The process of relating is also involved in that a knowledge test situation requires the organisation and reorganisation of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses. The Taxonomy uses, this analogy (p. 201): If you think of a mind as a file, in a test of knowledge you must find in each problem the signals, cues, and clues which bring out whatever knowledge you have filed.

Further, knowledge is broken down into types such as the following:

- **Knowledge of Specifics**: The recall of specific and isolable bits of information. The emphasis is on symbols with concrete referents.

- **Knowledge of Terminology**: Knowledge of referents for specific symbols (verbal and non-verbal).

- **Knowledge of Specific Facts**: Knowledge of dates, events, persons, places etc.

- **Knowledge of Ways and Means of Dealing with Specifics**: Knowledge of the ways of organising, studying, judging and criticising. This includes the methods of inquiry, the chronological sequences etc.
- **Knowledge of Conventions**: Knowledge of characteristic ways of treating and presenting ideas and phenomena.

- **Knowledge of Trends and Sequences**: Knowledge of the processes, directions, and movements of phenomena with respect to time.

- **Knowledge of Classifications and Categories**: Knowledge of the classes, sets, divisions, and arrangements which are regarded as fundamental for given subject field, purpose, argument or problem.

- **Knowledge of Criteria**: Knowledge of the criteria by which facts, principles, opinions, and conduct are tested or judged.

- **Knowledge of Methodology**: Knowledge of the methods of inquiry, technique and process employed in a particular subject field etc.

- **Knowledge of the Universals and Abstractions in a Field**: Knowledge of the major schemes and patterns by which phenomena and ideas are organized. These are the large structures, theories, and generalizations which dominate a subject field.

- **Knowledge of Principles and Generalizations**: Knowledge of particular abstractions which summarize observations of phenomena.

- **Knowledge of Theories and Structures**: Knowledge of the body of principles and generalizations together with their inter-relations which present a clear, rounded, and systematic view of a complex phenomenon etc.
Bloom categorizes the remaining five classes of behaviour as intellectual abilities and skills. Abilities and skills refer to organized modes of operation and generalized techniques for dealing with materials and problems. The objectives pertaining to abilities and skills emphasize the mental process of organizing and reorganising material to achieve a particular purpose.

- **Comprehension**: This represents the lowest level of understanding. It refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing the fullest implications (Bloom, 1956). There are three types of comprehension behaviour.

- **Translation**: Comprehension as evidenced by the care and accuracy with which the communication is paraphrased or rendered from one language or form of communication to another.

- **Interpretation**: The explanation or summarisation of a communication. Whereas translation involves an objective part-for-part rendering of a communication, interpretation involves a reordering, rearrangements, or a new view of the material.
Extrapolation: The extension of trends or tendencies beyond the given data to determine implications, consequences, corollaries, effects etc., which are in accordance with the conditions described in the original communication.

Application: The whole cognitive domain of the taxonomy is arranged in a hierarchy, that is, each classification within it demands the skills and abilities which are lower in the classification order. The application category follows this rule in that to apply something requires "Comprehension" of the method, theory, principle, or abstraction applied (Bloom, 1956).

This class of behaviour, therefore, requires the student to use abstractions in particular and concrete situations. The abstractions may be general ideas or they may be procedures, technical principles, and theories which must be remembered and applied.

The studies regarding taxonomic categories grew out of testing programmes at the University of Chicago. But such a system of classification can, inter alia, help in achieving both in teaching and in testing a desirable balance between purely factual objectives and those of greater complexity, involving comprehension and application of facts and principles. For a programmer the taxonomic categories may be used as a framework for viewing
the educational process. In classifying the terminal
behaviours for a unit of teaching, their correspondence
with the levels of learning may also be determined and
the entire teaching strategy may be adjusted to that
effect. This, however, does not exhaust other possibilities
of application of this system to programmed instructional
sequences.

SEX AS A VARIABLE

Sex has been included as another
variable in the present study since
it was thought to have an important bearing on mathematical
reasoning. L. Carmichael (1966), has collected sufficient
evidence to bring out sex differences in arithmetical and
mathematical reasoning. Carmichael contends that:

- Girls tend to excel on verbal types of problem,
  boys on quantitative or spatial.
- Achievement tests tend to indicate that girls
  are superior in all kinds of language material,
  whereas boys in science and mathematics.

Reilman's (1933) study of 10 year
olds in Denver brought out the fact that girls are superior
to boys in arithmetical computation test and that boys are
superior to girls in the arithmetic reasoning test. In his
monumental study of the mental and scholastic achievement
of London Children, Burt (1921), reported sex comparisons
in seven phases of arithmetical achievement for about 250
individuals of each sex at age levels from 8 to 12. In oral arithmetic boys were found to be superior at every age. In mechanical arithmetic the differences were unreliable except at age 12, where they favoured boys. In arithmetic problems, the differences were reliably in favour of boys at all ages and were particularly large at age 11 and 12. Again, Schiller's (1934) data for 189 boys and 206 girls in grade III and IV showed no appreciable sex differences in computation, but in arithmetical reasoning, boys were reliably superior. Cunningham and Price (1935), reported the results of arithmetic tests given to 40,000 children in Australia. In the four fundamental processes, the differences were small and inconsistent. In 'mechanical' arithmetic the differences all favoured boys but were not statistically significant. In 'problem arithmetic', however the differences all favoured boys and were highly reliable. In the work reported by Blackwell (1940), there is an interesting suggestion that the mental processes by which mathematical problems are solved get differentiated in boys and girls as development proceeds.

From the above studies, it seems that in arithmetical achievement the sex differences are small at the lower levels represented by routine computation and that they progressively favour boys as we move towards
the more complex levels of arithmetical reasoning. However, no studies are available for mathematical achievement and more specifically, for achievement in elementary algebraic concept and processes. It is quite conceivable that there may be significant sex differences in achievement in elementary algebraical concepts.

Considered in this light, sex in relation to learning Algebra through programmed instruction becomes an interesting subject of study and research.

THE CONTENT OF ALGEBRA

In the present study, elementary algebraic concepts and processes meant for the beginning students have been included. In particular, the following topics have been covered:

- Use of symbols
- Use of signs
- Use of simple brackets
- Algebraic expressions, terms.
- Product, coefficients and factors
- Very elementary knowledge of indices
- Substitution
- Simple addition, and
- Simple subtraction

THE PROBLEM OF THE PRESENT STUDY

The researches conducted so far reveal that the effect of step-size has either been studied
singly or in combination with variables such as cuing, response mode, immediate knowledge of results, motivation etc. Sex and taxonomic categories have rarely been taken into account. In fact step-size in relation to three levels of taxonomic categories has hardly attracted any attention of research scholars in the field. There can be little doubt that the development of programmed instruction on different levels of learning according to taxonomic analysis, assume a new dimension in the research field. If we combine all the three variables - step-size, taxonomic category and sex - and look at the research strategy in this perspective the following issues could emerge:

- What step-size for boys and girls together as also separately, is more effective in terms of scores on the criterion test?
- Is there significant interaction between step-size and taxonomic category?
- For what category of taxonomy is a particular step-size most effective?
- Is there any significant interaction between step-size and sex?
- Is there any significant interaction between step-size, sex and taxonomic category?

Considering the great significance and implications of these questions for the emerging educational technology, a specific study of a linear
programme on selected algebraic concepts and processes in relation to step-size and three levels of taxonomic categories was designed and the results are reported in Chapter 'Six'.

**SCOPE OF THE STUDY**

The scope of the present investigation has been delimited with respect to the type of the programme, the experimental variables, the tools employed to measure the criterion performance, the content selected for the programme and the design of the experiment.

For this study, six linear programme formats were constructed. Three forms of the programme developed at each of the three levels of taxonomic categories pertain to small step-size while the other three sets belong to large-step size.

The effectiveness of a programme is judged by learner’s performance on the criterion test. Therefore, three criterion tests each at knowledge, comprehension and application level of the taxonomic category were prepared.

The programmes were validated against the usual 90/90 standard and other criteria. The results of the total performance on the post-test highlight the effectiveness of the programmes. An achievement test, which represented all criterion behaviours, was also
developed. The test was used both as a pre-test and post-test measure. The small step and the large step forms of the programme were administered on four experimental groups of grade VI students in order to study the effect of step-size in relation to three levels of taxonomic categories.

A 2x2x3 mixed factorial design was employed for conducting the experiment and the results have been statistically analysed. The significance of the difference between the means has been found by using the usual F-test.

**RATIONAL OF THE PRESENT STUDY**

It is the common understanding now that while certain amount of evaluative research is necessary in order to contribute meaningfully to the basic concepts of programming, the major portion of the research effort should be devoted to the experimental analysis of the parameters which influence the effectiveness of the programme. Further, special attention needs to be paid to the size of the step. It is not only a difficult concept as it has been defined in different ways by different writers but also it holds a central place in the technique of programme writing. For example, when a student is taught a given subject matter, it is assumed that he starts off at a given level of proficiency and, after training, ends up at higher level. Now, one may attempt to go from the lower to the higher level
by presenting the learner with relatively few or many
steps. Further the size of the step is negatively correlated
with the number of steps. Thus, both number of steps and
size of step become important variables of which rate of
learning might be considered as a function.

The rationale of introducing
taxonomic category as the second factor in the present
study is based on the assumption that the efficacy of a
particular step-size is perhaps linked with levels of
learning. In learning at comprehension level, for instance,
the learner is required to interpret, extrapolate, generalize,
infer etc. It obviously depends upon a greater amount of
exposure of subject matter as compared to a situation in
which he has only to recall or recognize the content he had
encountered earlier. Again the learning at application level
is even higher than at comprehension level since the learner
has to make use of abstractions in particular and concrete
situations. Therefore, each of the two variables - step
size and taxonomic category - has important bearing on the
strategy of programming. A novice in programming technique
is always confronted with the problem of making decisions
about a particular combination of step-size and taxonomic
category.
Yet another variable - sex - has been introduced on the assumption derived from the studies conducted on arithmetical and mathematical reasoning and computation, that there are sex differences in learning elementary algebraic concepts and processes through programmed instruction.

The rationale for selecting the variables discussed above, is based on the results of research studies as also the available theoretical formulations about the technique of programming. The selection of algebraic concepts and processes as a topic for developing small-step and large-step programme is not arbitrary. The content on algebraic concepts falls within the cognitive domain and it can be conveniently and effectively presented at the three levels of taxonomic categories in a sequential way. Furthermore since there is a paucity of good mathematics teachers in the Indian context and also that students experience some difficulty in learning algebraic concepts it was considered useful to design such an experiment which may point out techniques for presentation of algebraic concepts and processes through programmed instruction.
OBJECTIVES OF THE STUDY

The present study has been conducted with the following main objectives:

- To examine the performance of students, with reference to small and large step sizes in a programmed material in algebraic concepts and processes presented in various taxonomic categories.

- To study the interaction of step-size with three taxonomic categories viz., knowledge, comprehension and application.

- To study the interaction of step-size, sex and taxonomic categories as mentioned above.

HYPOTHESES

On the basis of above objectives, the following hypotheses were formulated and tested in the present study:

- Small step-size presentation of the programme in elementary algebraic concepts at the knowledge level of the taxonomic category shows significant performance on the criterion test.

- Size of the step (small or large) in a programmed presentation in elementary algebraic concepts at comprehension and application level does not significantly affect the performance on the criterion test.
- For Programmed presentation in elementary algebraic concepts, boys would exhibit significant performance as compared to girls.

- There is significant interaction between step-size and taxonomic category for programmed presentation in elementary algebraic concepts.

- There is significant interaction between step-size and sex.

- There is significant interaction among step-size, sex and taxonomic category.

IN DEFENCE OF THE STUDY

The development of a technology of the instructional process is relatively new but as it happens, technology never sits still. Especially with the emergence of a growing sophistication in behavioural sciences, efforts are being perpetually made to improve learning and class room instruction. Programmed instruction in this respect opens up new vistas for change since the current emphasis in programmed instruction is to intensify the concern for improving the effectiveness of teaching by constructing material which will guide the pupil through a series of steps towards the mastery of specific learning problem. In this context, a study of linear programme on elementary algebraic concepts in relation to step-size and three
levels of taxonomic categories may immensely contribute towards developing a strategy of efficient and effective learning.

In the absence of definite research evidences, the problem of novice programmers gets unduly accentuated in form and intensity of effort. They often feel staggered at the initial stage of decision making with regard to programming. It can be reasonably hoped that the knowledge of effective step-size for particular taxonomic category will provide guide line to the perspective programmers in preparing programmed material.

Again, taxonomy is still regarded by many as a model for the selection of criteria for the construction of entire learning systems designed to achieve specified objectives. This specially holds good for programmed instruction. But taxonomic analysis of educational objectives has not been so far empirically tried out in combination with basic research issues regarding programmed instruction. It is, therefore, expected that significant findings of an experimental study with regard to taxonomic category may provide a solid base for its integration with programmed instruction for the purpose of teaching as well as testing.

If teachers are to play their vital role in revolutionising instruction, they will have to develop themselves as active class room researchers. Research
in programmed instruction, in particular, provides them a great challenge. In this context it may be relevant to quote appropriate part of a circular issued by the Ministry of Education, England (1967): "No teacher has ever wasted the time he has spent on the vigorous analysis of both subject matter and operations of thought, or the sources and types of error in learning — all of which are forced on him by the programme operation".

It is our expectation that a linear programme in elementary algebraic concepts and processes will not only be helpful for efficient teaching of Algebra, but also the findings of the present study will throw some light on basic research issues regarding programmed presentation of concepts.

DELIMITATIONS

The present study has been delimited with respect to the variables, content, sampling, tools and techniques at various stages.

The main variables of the study are step-size and taxonomic category. Six sets of the programmes have been developed embodying separately small and large step-sizes at the three levels of taxonomic categories. Step-size has been studied in relation to taxonomic categories.

Again in developing programmes in algebraic concepts and operations, only essential concepts have been included.
Another limitation of the study is regarding sampling. For conducting the experiment a sample of 300 students from six schools (three boys' and three girls') were taken. The sample was randomly divided into four treatment groups of seventy five students each. A 2x2x3 factorial design was employed to conduct the experiment and the findings were treated by the method of analysis of variance. No attempt was made to study the homogeneity of the groups as Edwards (1968) points out, the F test in the analysis of variance is quite insensitive to heterogeneity of variance.

Finally, the study may also suffer from some of the unavoidable limitations pertaining to tools and techniques. It may, therefore, be observed that the important findings accruing from the present research may be understood in the context of limitations outlined above.