# PROGRAMMED INSTRUCTION AS A LEARNING STRATEGY IN MATHEMATICS

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**Abstract**
*The present paper focuses on the learning of mathematics and is discussing the effectiveness of programmed instruction as a learning strategy. Programmed instruction with its basic principles of immediate reinforcement, self pacing , self evaluation, small steps is very appropriate for the learning of Mathematics. It help to individualize the learning and thus helps in catering individual differences and is beneficial for inclusive classroom. The paper focus on concept of programmed instruction and its effectiveness for mathematics subjects though review of related literature*

**Index terms:** programmed instruction, styles of programme learning material- linear, branching and Mathetics.

## Introduction

The teaching learning process of any subject basically involves three steps- formulation of objectives, designing teaching learning situations and evaluation. All these steps are inter-dependent; the nature of objectives will determine the learning situations and evaluation techniques. The nature of knowledge of Mathematics emphasizes on the development of skill in students of solving the mathematical problems accurately and rapidly as well as cognitively able to apply and analyze the comprehended mathematical concepts and terminologies. Accordingly the evaluation techniques should also be able to evaluate these cognitive abilities in students in a psychological way based on the principles of motivation and being stress free. Mathematics being an important subject for the students due to its utilarian, practical, occupational and aesthetic values, it is equally important to design its learning situation with utmost care. The appropriate teaching methods, proper provision for remedial lessons, motivating and stimulating environment is very important in Mathematics teaching to build a strong foundation of Mathematics which will lead to high achievements and thus a growing interest towards the subjects in the students. The basic problems of today's Mathematics classroom is that skill and application objectives are not given due weightage rather there is more focus on learning the concepts, theories and formulae, students are not immediately provided with feedback of their work , all of the 40-50 students in the classroom are forced to move at the same pace regardless of preparation and abilities and the third is that instead of considering errors made by students a way for peeping into their minds to take guidance from them for future steps they are neglected or students are scolded for them which leads to a hostile learning environment in the classroom.
. There is need of methods which are based on the following principles-

- ❖ Principle of integrating theory with practice
- ❖ Principle of learning by doing
- ❖ Principle of moving from known to unknown
- ❖ Principle of motivation
- ❖ Principles of feedback or knowledge of results

There are continuous efforts from psychologist and educationist to device such methods of teaching mathematics which are based on above stated principles and which meet the demand of the various theories of learning mathematics. One of the important theories of learning mathematics is connectionist theory. Although Thorndike's influence on the teaching and learning of mathematics was for the most important but it was under the leadership of B.F.Skinner and Robert Gagne that connectionist oriented theories of mathematics experienced a rigorous revival. In his autobiography Skinner mentioned his experiences of 11th November '1953 when he visited a fourth grade arithmetic classroom- "the students were at their desk solving a problem written on the blackboard. The teacher was looking at their work pointing to mistakes here and there. A few students soon finished and were impatiently idle, others with growing frustration strained. The papers were then collected, graded and returned next day". Reacting on this situation he commented – "***I***

***suddenly realized that something has to be done."Possibly though no faults, teacher was violating two fundamental principles: the students were not being told at once whether their work was right [a corrected paper seen twenty four hours late could not act as reinforcer] and they were all moving at the same pace, regardless of preparation or ability***."

Thus we see that two major problems on which to concentrate to improve mathematics teaching are those of catering to individual needs and second to provide immediate reinforcement to maintain the motivation of students.

In his famous article – "**the science of learning and arts of teaching"** Skinner stated that most important criticism of classroom is the relative infrequency of reinforcement. Since the pupil is usually dependent upon the teacher for being right and since many pupils are usually dependent upon the same teacher, the total number of contingencies which may be arranged during the first four years is of the order of only a few thousand whereas the lapse of only a few seconds between response and reinforcement destroys most of the effect.

The learning can be strengthened and motivation can be maintained only when students are given immediate feedback of their answers.

The solution to the problem is to divide the content matter to be taught into a very large number of very small steps and reinforcement must be contingent upon the accomplishment of each step.

Diversity of student is other major challenge which the mathematics teacher meets in the classroom. We can watch in any classroom that while some students have already solved the given mathematics problem and are asking for further challenges others have not even taken up their pencil, whereas some students are trying to solve new mathematics problem with enthusiasm and creativity others cannot even start working and do not have confidence in their own capabilities. Thus we see differences among students are perhaps most notable in the amount of time and energy required by students of differing degree of abilities and interest to attain comparable level of learning. So it is important that the strategies of mathematics teaching be so devised that need of individuals are met. In 1986 Girdharilal studied the effect of the individualized and conventional instruction and found that individualized instruction was more effective in terms of mathematics achievement.

The other important factor in mathematics teaching is that to develop a cordial environment. A hostile learning environment where pupils are scolded for making mistakes is hardly supporting for appreciating and liking mathematics. The errors made by the students should never be neglected and students should never be scolded for them but teachers should try to find the logic behind the particular answer. Each answer given by students should be accepted and children should be encouraged telling why they gave a particular answer. These mistakes by the students should be considered as a way for peeping into their minds and the learning of concepts should be promoted taking guidance with these mistakes.

The interview of the teachers conducted by the author supports the fact that there is need of individualized instruction in mathematics classroom. Teachers expressed their inabilities to meet the individual demands of the students in a class of forty to fifty students during the time of one or two periods.

Above discussion raises few questions that how in a classroom of forty to fifty students teachers can provide immediate reinforcement to every child, which strategies be selected which will present the content matter before each student according to his own pace and abilities and third is, in which way errors can be utilized to provide remedial teaching to students.

Teaching learning strategy which can be an answer to all the above questions is Programmed instruction

According to skinner's analysis adequate establishment of mathematical behaviour during the first four school years would require between 25,000 to 50,000 response-reinforcement situations, a task clearly impossible in the traditional organization and teaching methodology of school. He then proposed that **programmed instruction units** based on the connectionist principle of reinforcement would be the most effective means for bringing about learning. (*The encyclopedia of education, 90-93).*

**History of programmed Instruction**:

The emergence of the present form of programmed instruction is from the processes that have evolved down through the ages and include the contributions of scholars dating back to more than 2000 years.

One of the earliest programmers was Socrates who developed a program for geometry which was recorded by Plato in the dialogue Meno. Socrates taught a slave boy the proof of Pythagorean Theorem by using simple diagram and leading the boy by small steps to generalization of some specific significance. (*Lysaught and Williams (1963), 3).*

Tutorials are also considered a form of programmed instruction. The continuous exchange of questions and answers between the tutor and his students in the tutorial method, the unfolding of information and explanation and constant selection of new material on the basis of students mastery of what has gone before is indeed a forerunner of programmed instruction.

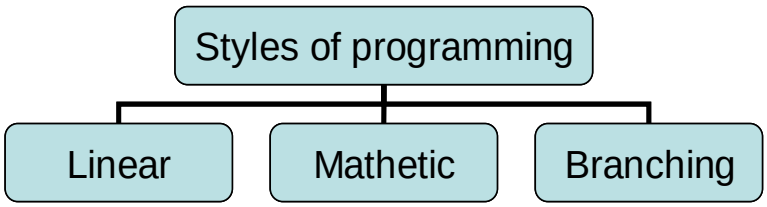
Thus we see that origin of programming is not essentially new, nevertheless the method as it is now employed may be considered to derive from dynamic efforts that began in 1920's.
In 1926 Sidney L. Pressy, an Ohio state university psychologist made public his pioneer study on the first recognized teaching machine. Pressey's model presented a series of questions to a student and informed him immediately whether his answer was right or wrong. In most respects Pressey's machine had the same capabilities as the machine now in use but the movement in behalf of such devices lost due impetus which got revival again in 1954 when B.F.Skinner read his paper entitled " ***the science of learning and arts of teaching"***. This paper gave way to programmed instruction as a somewhat self conscious movement.

**Concept of Programmed Instruction.**

Program is an old term. It connotes a predetermination of order, of sequence and fixed relationship of interdependent function or actions to be performed
Programmed instruction as defined by Markle is a "***reproducible sequence of instructional events designed to produce a measurable and consistent effect on the behaviour of each and every acceptable students***." The definition uses the term "instructional events" which are caused by different type of programmed instructional material like book formats or teaching machine.
James E. Espich and Bill William defined programmed instruction as a "***planning sequence of experiences leading to proficiency in terms of S-R relationship that has been proven to be effective.***" They considered a program to be an educational device that will cause a learner to progress through a series of experiences that the programmer believes will lead to the student's proficiency. The use of the term "experience" in the definition implies that the student must participate in learning processes. "Planned sequence" means that the person developing the program has determined not only what experiences the learner should have but also in what order they should occur. The term S-R relationship refers to the basic behavioural concepts on which programmed learning is based. (*Gupta, 238-239).*
Some of the things programmed learning does is to make each learner's experience an individual affair and to maintain a constant interaction between a student and his learning material. As it strengthens the motivation to learn by frequent reinforcement so it cuts down frustration by placing mastery of subject matter within any student's grasp. Moreover programmed learning improves the student's readiness and makes him active learner.
Programmed learning affects the stimulus by acquainting the student with only one item at a time and by presenting the total number of stimuli in a sequence that leads to greater understanding. It governs the response through instant check of replies and through consistent immediate reinforcement of the learning it wishes to impart. Programmed learning insists that each single point be understood before the student moves along to the next one limiting itself at each step to the material for which the student has been prepared. Besides, it offers a mechanism for coping effectively with the range of individual differences in ability among students.

**Styles of Programming**:

Styles refer to the arrangement of material to be learnt in order of presentation which will maximize the rate of acquisition and retention. By now three distinct styles of programmed instruction have emerged.



1) Linear programming or extrinsic programming

Historically the first style of programming was the one called "linear" derived in part from skinner's suggestions and part from the characteristics of the first teaching machines. (*Suzane (1969), 1)*. Linearity means that each student proceeds in a straight line through a fixed instructional sequence.
This style postulates that a desired change in behaviour can best be brought about by inducing and then reinforcing the desired behaviour. This is achieved by developing small learning steps, technically called "frames". The subject matter is presented as incomplete statements with some blanks. The learner is required to read the frame and construct a response for each blank. After he has formulated his response he is required to compare it with the correct response.

1) Mathetics:

The systematic procedure of Mathetics was first described in 1962 in a pair of article by Gilbert. Mathetics follow the sequence called retrogressive chaining. The retrogressive chaining technique is basically teaching the mastery step first. The mastery of the subject matter is the main focus of Mathetics. It involves three principles chaining, discrimination and generalization. In Mathetics the mastery unit is divided into small steps and they are arranged in learning sequence with the help of chain.

2) **Branching programming or intrinsic programming**:

Branching programming got started by way of an ordinary practical training. In 1954, Norman Crowder a psychologist with United Nations Air Force was asked to investigate the training of aircraft maintenance men. These technicians were taught to repair faults in a bomber navigation system. He had to find a way of giving his trainees the training under the guidance of a live human tutor without actually calling for the presence of that tutor. He solved his problems with the aid of a film projector, a screen and a panel of buttons. He built a stimulator which worked by giving to the individual trainee, units of information about specific faults in bomber navigation system and posing multiple choice questions that required him to choose a means of remedying the situation. If he made an error he would be given extra instructions. This gave birth to branching programming. (*Row tree (1966), 5-7).*
The basic structure of intrinsically programmed material is very simple. In each program step the student is given a unit of material to read usually a paragraph of 80 to 70 words, followed by multiple choice questions. The student answer choice determined directly and automatically what material he will see next. If he chooses right answer he is automatically presented with new paragraph. If he chooses an incorrect answer he is presented with material written to correct the particular error he has made. At the end of the correctional material the student will in the simplest case be directed to return to the original presentation to have a second try at original question, having completed a first order branching. However the material may be the start of a "subprogram" of material and questioning in which the point is explained in smaller steps with a different approach. This will be second order branching. The crucial and identifying feature of intrinsically programmed material is that it does not aim to eliminate error but it works on possibility of detecting and correcting errors.
A standard mainstream frame of branching program in an instructional page contains six parts-

a) The answer the student chose in the last frame
b) Feedback or discussion of why the answer is correct
c) New information
d) A question testing his comprehension of new information
e) Two or more alternative answer to select from
f) A page number telling him where to go next for each alternative (Suzane ( 1969), 188-206)

Review of related literature of the studies related to programmed learning material in Mathematics indicate that many researchers through their study found programmed instruction as an effective tool for learning Mathematics.

Conclusion – the discussion in the paper clearly reveals that programmed instruction can be utilized in the teaching earning process of Mathematics, being an individualized strategy it will help in catering individual needs especially when we are aiming for inclusive classrooms. The computer assisted learning materials developed on principles of branching programme can be an effective tool for the techno-savvy students. It is good technique for self evaluation and building in student's confidence and developing a sense of responsibility. The studies conducted on programmed instruction revealed the favorable reaction of students towards using programmed learning material. Programmed learning material has many advantages , it can be

used a learning strategies, if developed as computer learning material it can be utilized as Mathematical games for primary classes as well as it can be used as remedial and self assessment tools. There is a need of the practical applications of researches done on programmed learning strategies and apply it in actual learning setting

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