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CHAPTER III

DEVELOPMENT OF THE INSTRUCTIONAL MEDIA

3.1 Introduction

Almost every educational reformer has expressed deep concern over the excessive use of words that carry the shadows of meaning but not the substance. Several educationists have struggled to make education realistic. About three centuries ago, J.A. Comenius prepared the first visualised text book which contained some 150 pictures. He added that pictures are the source of delight to the children and hence, children should be familiar with pictures before they enter school. Later J.J. Rousseau criticised the teaching of his days and condemned the liberal use of words by teachers. According to him, the teaching process must be directed to the learner's natural curiosity. Rousseau's theory was put into action by Pestalozzi in his 'object method'. His interest was in basing instruction on sense perception. Although, attempts on the use of concrete aids were made sporadically, intensive development in audio-visual education started in the twenties of this century. Today audio-visual aids have been accepted by almost all the educationists without having sufficient evidences about their effectiveness. It has become a fashion to refer to audio-visual aids wherever there is a concern for instruction.
Audio-visual aids are the different types of tools that appeal to the sense of hearing and vision and are used in classroom for presentation of abstract information. Some audio-visual aids like motion film, slide or filmstrip need a projector to handle. Some other like a chart or picture need no equipment and can be directly used. Hence, the term 'audio-visual aids' designates in common usage both processes and material things. Educators often refer to describe the field of audio visual education as 'educational communication technology', 'audio-visual media', or 'instructional media' mean the same thing. All these are implied by the term media. More specifically, media refers to films, slides, pictures, charts and programmed instructions. Instructional media are the devices which act as middle conditions between pupils and what he has to learn. An instructional medium is simply a means of transmitting instruction, i.e. simply a means of providing learning experience. It serves as the channel of instruction. As such instructional media play significant role in the process of instruction. In the following lines the investigator has made an attempt to discuss role of instructional media in the process of instruction.
3.2 Role of instructional media

Instructional media, in any field of education is identified considering the features of the instructional process, which have been formulated in the light of the objectives set for. Instructional media, are to be used effectively to make process of teaching learning effective by means of educational devices and equipment. Instructional media are widely used because of their following role in instructional process.

(1) By using instructional media, inaccessible process, materials, events, objects, changes in time, speed and space could easily be brought to the class. Teachers often face difficulties in making information available to pupils in certain cases. Pupils in a large classroom may not be able to see the demonstrations, small models, or smaller objects shown by the teacher. Further, the teacher may not be able to show the microscopic things to the whole class. Sometimes different types of instruction and guidance may be needed for individual pupils. Instructional media can help the imaginative teachers to solve all these communication problems. Instructional media provides the teacher with a means for extending his pupils' horizon of experience. They equally help the teacher to provide his pupils with meaningful source of information.
(2) Use of instructional media results in greater acquisition of knowledge of facts and ensures longer retention of information gained as they provide multisensory experiences. Instructional media provide first hand experience in a variety of ways and sometimes make the pupils to participate actively. Hence, they not only help to develop meaningful vocabulary but also enable the pupils to remember facts for a pretty long time.

(3) Use of instructional media, in classroom can provide effective substitutes for direct contact of pupils with environment - social and physical. Some media may serve as a magic carpet for providing needed experiences. Motion pictures, television and carefully prepared slide sequences would be particularly valuable. These stimulate pupils' interest.

(4) With the use of suitable instructional media, any expected change in attitude and behaviour could be facilitated. Instructional media generally add an interest and involvement in the teaching learning process. Active participation maintains interest and increases learning.

(5) Proper instructional media can provide integrated experiences varying from abstract to concrete. They supply concrete basis for conceptual thinking, giving rise
to meaningful concepts. Audio-visual technology presents abstract information to the learners in various forms. They enhance clarity of communication and increase speed of comprehension.

(6) Instructional media offer rich opportunities for pupils to develop communication skills.

(7) Instructional media could be used to motivate and stimulate interest of pupils to gain further knowledge. Interest is not an end itself. Interest that has been created by means of an instructional aid must act as a spring board for launching the pupils into a wide variety of learning activities. Instructional media can develop an awareness of problems, open up possibilities for exploration.

(8) Instructional media can be used advantageously for any age or ability groups. In a conventional teaching method, the teacher is the centre of attention and the primary source of information. Instructional media can be used as supplements to illustrate, to clarify and to focus attention. Pupils can learn using media at their own pace. The particular pupil using the programme receives immediate confirmation of responses made by him. Advantage of visual projection, is the resulting high
magnification of the image formed on the screen which can be easily seen by all.

(9) Instructional media provide the teacher with tools to carry out diagnostic testing, research and remedial work.

Thus, instructional media help the pupils by creating more vivid impressions, by using additional organs of sense, by getting and holding the pupils' attention through change of pace, by simplifying the knowledge to be imparted and by improving the quality of instruction provided. In short, pupils are said to: (i) learn more; (ii) remember longer; (iii) learn faster; (iv) learn uniformly; (v) give better attention; (vi) have better morale through instructional media. Of course, these claims are largely unsupported by evidences. They are surmised, however, to have the qualitative and quantitative values mentioned, but little has been done to validate the claims. Research is badly needed in this area.

3.3 Criteria for selection of the instructional media

Instructional system like any other behavioural system, has so many variables affecting. Therefore, the process of selection of media should be guided by these
variables, besides the important criteria of the nature of the instructional objectives. These criteria are as follows.

(i) **Nature of instructional objectives**

According to nature of instructional objectives, the way the pupil ought to interact with the subject matter differs. This is possible in mediated forms in which subject matter is to be presented. For example, if the objective is to impart basic information, certain media may prove to be better than others. If it is to develop higher cognitive abilities, certain other media may be more effective. Instructional objectives may be broadly classified as cognitive, affective and psychomotor; and may further be classified into intellectual skill, cognitive strategy, verbal information, motor skill and attitude.

(ii) **Characteristics of the learner**

With the change in the characteristics of the learners, there may be variation in their mode of interaction with the subject matter. Therefore, the selection of media should be based on these characteristics. Age, size of the target population, intellectual level, language spoken, level of abstraction, interest level, challenge, preparedness, special environment etc. from the characteristics of the learner.
(iii) Characteristics of the subject matter

Every discipline has got an unique structure. The possible ways in which content matter can be treated also depend upon its structure. This means a particular media may be more suited for a content belonging to a certain discipline by virtue of its structure. Therefore, at the time of media selection, one has to look into the nature of subject matter too.

(iv) Resources available

Availability of resources forms an important criterion of selection of media. Resources include finance, time, physical facilities hardware materials, man power etc.

(v) Attributes of the media

As Levie and Dickie (1973) conclude, media attributes are properties of stimulus materials which are manifested in the physical parameters of media. In other words, it is the capability of a medium to show objects in motion, in colour, in three dimensions, to provide printed words, spoken words, simultaneous visual and auditory stimuli, to allow for overt learner response, etc. When media are defined in terms of gestalts formed by combination of various elements, which result in
particular modes of communication, it can be concluded that media attributes are unique modes of interaction that a medium is capable of presenting. Hence, one has to take media attributes into consideration while selecting the media.

(vi) **Cost and time involved**

Besides the physical attributes, other important characteristics of a medium are the cost and the time involved. These also are to be brought under consideration while selecting the media.

The interplay of the above mentioned factors and their relationship with the output variables should be studied and determined. Without this, the process of selection of media would remain subjective. That is, it would be on the basis of personal preferences, institutional biases or pressures of advertising and sales. To place this process of selection on a scientific footing, it is necessary to have researches to empirically establish the relative effectiveness of one medium over its alternatives in given contexts. Only such research findings would provide enough insight and thorough basis as to enable prediction of the suitability of a particular media in particular instructional context. In this context, the present investigator had decided to develop three
instructional media for two units of mathematics. Development procedure of these media have been discussed in the following lines.

3.4 Development of the instructional media: I
(Visual projection)

Audio-visual aids are chiefly used as classroom communication devices, since they help to clarify, establish and correlate accuracy, concepts, interpretations and appreciations. These also increase knowledge, arouse interest and even evoke worthy emotions and enrich the imagination of the learners. Visual projection supplies a concrete basis for conceptual thinking. They give rise to meaningful concepts to words enriched by meaningful associations. Researches have also recommended that in education one should appeal to the mind, chiefly, through the visual and auditory sense organs as it is possible that 85 per cent of learning begins at this terminal points. Audio visual aids are potent starters and motivators. They do add variety to classroom technique. The detailed procedure for developing instructional media: I namely, visual projection have been discussed under the following four major heads.
3.4.1 Selection of teaching units

Since the purpose of the present study was to compare the efficacy of the three instructional media, the teaching units were meant to serve as mere carriers for them. Therefore, care was to be taken not to introduce new extraneous variables due to the teaching units. Though, the experimental design itself introduce sufficient control in this regard, it was felt that effort should be made at the time of selection of teaching units to minimise extraneous variables. Therefore, the investigator maintained the following considerations at the time of unit selection.

(i) There should be minimum pre-supposed concepts.

(ii) There should be minimum inter-relationship between the selected teaching units. These were taken into consideration, so that the carry over effects from one unit to another, during the course of the experimentation could be avoided.

(iii) There should be similarity in the structure of these two teaching units, means all the three media should be applicable to these units. This was taken care of to make these units equally adoptable to each of the three instructional media under comparison. This was done to minimise interaction effect, if any, between media and teaching units.
(iv) The difficulty level of the two teaching units should be almost equal. This was considered, so that, the play of their differential interactions with the attributes of the learners could be minimised.

Content experts and professional teachers were consulted and finally two teaching units viz., (i) Factorization of the type $a^2 - b^2$, (ii) Expansion of $(a + b)^2$ were selected from algebra of standard IXth.

3.4.2 Objectives of the teaching units

Following objectives were decided by the investigator for the selected teaching units.

Unit : I

(i) To enable the pupils to acquire the knowledge of factorization of the type $a^2 - b^2$.

(ii) To enable the pupils to comprehend the factorization of the type $a^2 - b^2$.

(iii) To enable the pupils to apply the knowledge of factorization of the type $a^2 - b^2$.

(iv) To enable the pupils to develop their computational skill.
Unit : II

(i) To enable the pupils to acquire the knowledge of
expansion of \((a + b)^2\).

(ii) To enable the pupils to comprehend the expansion
of \((a + b)^2\).

(iii) To enable the pupils to apply knowledge of the
expansion of \((a + b)^2\).

(iv) To enable the pupils to develop their
computational skill.

3.4.3 Preparing transparencies

The investigator decided to prepare hand made
transparencies for both the units. Two plastic rolls
long enough to cover the required teaching points and having
7 inch width, were selected for preparing transparencies.
Necessary diagrams to get the required formula were drawn
on the transparent rolls with good quality of permanent
ink. Along with diagrams, required illustrations were
also noted on the transparent rolls with permanent ink.
Some main points, some examples were also noted for
drill work. Some examples were noted with some missing
steps to initiate discussion. Thus, keeping in mind
all the teaching points, the required frames were noted on
the transparent rolls keeping distance of at least one
inch between each frame. The transparent roll was left blank at the end so that some more examples can be discussed at the end. Thus, two transparencies were prepared with permanent ink. So that these rolls can be used repeatedly.

3.4.4 Projecting transparent roll through over head projector

The apparatus, which is so devised that the transparent roll put on the light source and their images are projected overhead, from a short distance, on the screen in front of the pupils and an operator (teacher), is called overhead projector. It enables the teacher to face his pupils even while projecting something on the screen beside him. Teacher can write or draw in the course of the lesson, and this writing or drawing is shown on the screen. It has the merits that any dark room, as required in case of slides, films, is not needed, but clear pictures can be projected in a bright class room and that a teacher can directly give instructions to pupils by presenting teaching material face to face with them.

The following procedure was followed to project the required transparent roll.

Projector was set up at the front of the room with the projector lens facing the screen. Investigator
carried out this projection in a laboratory, switch was turned and transparent roll was placed on the glass top with right side up. After this, projector lens was adjusted until image in sharp focus. Thus one by one each frame of transparent roll was projected. At each frame some questions, planned in advance, were also presented for further discussion. Pupils were stimulated to think by injecting questions, by asking them to read on screen. Thus, this instructional media was developed for both the teaching units (vide appendix 1 and 2).

3.5 Development of the instructional media : II
(Activities and experiment)

Activities and experiment are the cardinal principle of the child behaviour. The child is active by nature, child desires to deal with things, to make, to construct, to destroy, to observe and to enjoy. The experiment method aims to arouse teachers to a belief not only theoretical but practical and effective also, that mathematical dishes must be made appetizing and palatable. John Dewey (1938) emphasises that direct experience is the basis of all method. To him knowledge should arise from concrete, and meaningful situations. Hence, spontaneous activities must be given to pupils. 'Learning by doing' is the core concept of pragmatic philosophy. It is
the main psychological principle that is behind the activity work in all the subjects including mathematics. Education psychology lays more stress on concrete work and on a learning that rises from one's own experiences. These experiences are gained through activities. For activities pupils must get chance to workout the experiments individually or in a group. Mathematics should be made to grow out of sense impression and in teaching mathematics, aim should be to pass from concrete to abstract. While teaching, it is better to start with important educational maxim 'concrete to abstract'. By concrete illustrations, abstract rules or ideas arrived at by the inductive method are readily accepted by pupils. Pupils doing some work have more interest in it and will have better understanding of the matter. The detailed procedure for developing the instructional media: II namely Activities and experiment have been discussed under the following four heads.

3.5.1 Selection of teaching units

Two units of algebra were selected with the same considerations mentioned in caption 3.4.1 (P. no. 75). Two units were selected in such a way that some activity and experimental work can be given to pupils. Materials for this media were prepared for both the teaching units.
3.5.2 Objectives of the teaching units

Objectives as mentioned in caption 3.4.2 (P.no.76) such as, knowledge, comprehension, application of knowledge and development of computational skill were kept in mind while developing this instructional media.

3.5.3 Preparation of materials for Activities and experiment

The investigator prepared materials which can explain the factors of the type $a^2 - b^2$ and expansion of $(a + b)^2$, 25 wooden squares of the same size with different colours were prepared. Using these squares all the three identities were derived with the help of pupils' participation. Along with wooden squares charts representing the same things were also developed for better understanding.

3.5.4 Procedure for development of the unit during instruction

For the first algebraic identity pupils were asked to draw a square of length 'a' and then they were asked to cut a square of length 'b'. Area of square with length 'b' was subtracted from the area of square with length 'a'. Finally, they themselves were asked to find
out remaining area and to prove the identity

\[ a^2 - b^2 = (a + b)(a - b). \]

For the expansion of \( (a + b)^2 \) pupils were asked to draw a square with length \( a + b \) and the same square was divided in four parts, such that two of them are squares with area \( a^2 \) sq. units and \( b^2 \) sq. units respectively. Remaining two were rectangle with area \( ab \) sq. units each. It was proved finally that area of the square with length \( a + b \) is equal to area of all four parts. Thus \( (a + b)^2 = a^2 + 2ab + b^2 \) was proved.

For the third identity pupils were asked to draw a square of the length \( a \) and then to cut a square of length \( a - b \) in the same square. Whole figure was divided into four parts with two of them squares and two rectangles. Finally, area of square with length \( a - b \) was obtained by subtracting area of remaining three parts from the area of whole square to get the result \( (a - b)^2 = a^2 - 2ab + b^2 \).

Thus, using the knowledge of area of square and rectangle the required identities were obtained. All the pupils were asked to draw the required diagrams in their note books and they themselves obtained the results. Here, all the pupils were actively engaged in getting required
results by experimenting themselves. Few more illustrations were also taken and pupils were asked to draw diagrams for these illustrations to drill the required results (vide appendix 3 and 4).

3.6 Development of the instructional media: III

(Programmed learning material - PIM)

Science and technology have touched almost all aspects of human life and programmed learning is an application of behavioural science and technology in the field of education. Keeping in view the large quantum of knowledge to be imparted to larger population with minimum resources, with a limited time, programmed learning has shown a new path towards automation and individualization of instruction.

Programmed learning is much broader and comprehensive concept. Susan Markle (1969) defined programmed learning as a

"method of designing reproducible sequence of instructional events to produce a measurable and consistent effect on the behaviour of each and every acceptable student" (P.104).
Programming is the process of arranging the material to be learned into a series of small sequential steps. Usually, the pupil moves from a familiar background into a complex and new set of concepts and understanding. It encourages self-study at one’s own pace since its design presents a carefully arranged logically sequenced set of material with pupils' responses, being reinforced at each step. As a result of which pupil can progress towards the desired behavioural capabilities. This feature makes the PIM (Programmed learning material) more suitable as teaching material, particularly at secondary school level. This not only provides efficient learning but also makes the learners independent in their thought and actions and at the same time saves pupils' and teachers' time.

Planning of programme should be so extensive and detailed that it becomes a model for final product. Generally, planning covers the following aspects of a programme.
The investigator has tried to discuss all the above mentioned aspects in the context of development of programmed learning material in the following seven heads.

3.6.1 Selection of teaching units

Two units of algebra from the text book for grade IX were selected. These two units were selected with the same considerations mentioned in caption 3.4.1 (P. no. 75)

3.6.2 Specification of behaviour

One of the outstanding contributions that programmed instruction has made to educational practice is its emphasis on the importance of specifying educational objectives in terms of specific behaviours. Behaviour is any visible activity displayed by the learner and hence, can be observed and measured. The objectives should be stated in meaningful terms in the form of observable and measurable behaviours. Meaningful objectives describe the product, depicting what the learners will be, as a result of the process.

What are the pupils expected to do after learning a particular unit through PIM? How will the teacher know what and how much have the pupils attained?
These are very crucial problems which are to be answered before the actual instruction is started. The terminal behaviour, as it is known in programmed learning language, tries to answer all the queries mentioned above. The emphasis laid on two important points in the statement of terminal behaviour are, (i) observable behaviour, (ii) measurable behaviour. Behaviour refers to any visible activity displayed by a learner. How well was the activity displayed can be judged only if one has some means to measure it. Hence, observable and measurable are the key words to be kept in mind while specifying the behaviour before starting programming. These behaviour can be divided into two categories namely, (i) entering behaviour and (ii) terminal behaviour.

(i) **Entering behaviour**: Any experiment which includes teaching of certain content matter, often demands assumption regarding the behaviour of the pupils prior to conduct of the experiment. In other words, an investigator has to determine what behaviour the learners shall already have at the time of understanding the selected units for the experiment. A list of such behaviours form the entering behaviour. Entering behaviour has been much less discussed to programming literature than terminal behaviour but, it is of no less importance.
The entering behaviour of the pupil determines the level at which the programme must start and provides the base upon which the programme develops. It determines initial competencies and skills with which the pupil begins the programme. The information regarding entering behaviour may include previous experience, aptitude, age, interests, ability and level of attainment in a particular subject of the pupils for whom the programme is planned.

Following assumptions about entering behaviour of learners were made by the present investigator:

(i) The learners had equal vocabulary in Gujarati language.
(ii) The learners had similar background in the subject of mathematics.
(iii) The learners were from the same age group.

Further it was assumed that pupils will be able to...
- identify the squares and rectangles
- state the formula for finding the area of a square
- state the formula for finding the area of a rectangle
- compute area of a given square
- compute area of a given rectangle
- state the meaning of factors
- say the square of a given number
- say the factors of given numbers
- draw the squares and rectangles.
(ii) **Terminal behaviour**: It is an analysis of the behaviour which a particular content matter taught through a teaching technique is intended to produce in a learner. In other words, one who undertakes to teach through any instructional media has to analyse the behaviour involved in the instructional process. One thus formulates the instructional objectives in terms of expected terminal behaviour of the pupils, i.e. what the pupils are expected to achieve and attain after studying a particular content matter through a specific instructional media. The terminal behaviour laid down for the programmes for unit: I and unit: II are as follows.

**Unit: I  Factorization of the type $a^2 - b^2$**

After completion of the programme, the pupils will be able to ...

- derive the formula for factors of $a^2 - b^2$.
- state the factors of the type $a^2 - b^2$.
- identify the correct factors for given example.
- fill in the gaps by putting correct answer.
- compute the values in a given example.
- convert the problems in the form of $a^2 - b^2$.
- write the steps in logical sequence.
- write the factors for given examples directly.
- Calculate the values of given arithmetical problems without error.
Unit : II  Expansion of \((a \pm b)^2\)

After completion of the programme pupils will be able to ...

- derive the formula for \((a + b)^2\)
- derive the formula for \((a - b)^2\)
- state the expansion of the type \((a + b)^2\)
- state the expansion of the type \((a - b)^2\)
- explain the relation between three terms in the expansion
- select the correct expansion for a given example
- fill in the gaps by putting correct answer
- compute the first term in the expansion
- compute the middle term in the expansion
- compute the third term in the expansion
- write the step in logical order
- express the given number in the form of \((a + b)^2\) or \((a - b)^2\)
- calculate the value of given arithmetical examples without error.
- apply the method of \((a + b)^2\) in finding the values of given arithmetical examples.

3.6.3 Developing criterion test

Entering behaviour indicates the minimum competence which makes the pupil eligible to take a programme.
Terminal behaviour indicates his changed or modified behaviour as a result of programmed learning material. The test to assess whether the behaviour has been modified in the desired or expected direction is known as 'criterion test'. From a criterion test one can judge the extent to which behavioural objectives are attained. Unlike an achievement test its objective is not to discriminate between good and bad pupils but, to know whether he has arrived at the criterion behaviour or not. An additional advantage of a criterion test is that it provides necessary feedback to the investigator for reappraisal of the sequence to the given programmed learning material. Keeping in view the specific objectives and terminal behaviour for both the units, the investigator prepared the blueprints for constructing the criterion tests. The first draft of the test for each unit was evaluated so as to ensure the coverage of behavioural objectives. With the help of subject expert and evaluation expert certain modifications were made in the first draft of each unit. After this, second draft was ready for try out. Second draft was tried out on a small group of pupils to judge the effectiveness of instructions for a test and also instruction for each question. On the basis of this try out, certain modifications were carried out and also time limit was decided for the test. Then final draft was prepared for both the units. Criterion
tests, one each for both the units consisted of five questions. Fifty marks were assigned to each criterion test. Types of test items and marks allotted are as follows.

**Criterion test for unit : I**

<table>
<thead>
<tr>
<th>Question</th>
<th>Type</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 items of fill in the gaps</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>type</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5 items of matching type</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>9 short answer items</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>5 items of true or false type</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>4 short answer items</td>
<td>12</td>
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</tbody>
</table>

50. total marks

**Criterion test for unit : II**

<table>
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<tr>
<th>Question</th>
<th>Type</th>
<th>Marks</th>
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</tr>
<tr>
<td>2</td>
<td>5 items of matching type</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>5 items of true or false type</td>
<td>5</td>
</tr>
</tbody>
</table>
3.6.4 Task analysis

Task analysis is the most important step in the process of developing programmed learning material. To justify the importance of task analysis, Latterner (1969) says:

"The investigating analyst must do this for two reasons, first to clarify the overall purpose of the job; and second, to show the task relationships as the job progresses to the completion of the work cycle. Failure of the analyst to explain why an activity is undertaken will leave the impression that the job has not been fully reported, and this can result in ambiguity in preparing training materials" (P. 54).

Popham and Baker (1970) says that:

"Among the most serious problems facing an instructor is the decision about what he should do to help his students to achieve his desired objectives. Certainly the statement of explicit behavioural goals is a necessary pre-condition..."
for planning effective instruction. However, it is clear to any one who ever tried it that the statement of behavioural objectives does not solve the total requirements of instructional design. A teacher still must have some way of identifying and ordering the activities that will optimize his chances of being successful" (P. 45).

Task analysis includes analysis of terminal behaviour and also analysis of all the activities that the learner has to do during the instructional process. It should also identify and describe the sequence of activities taking into account the concepts and skills involved in them. Entering behaviour and terminal behaviour have been listed in caption 3.6.2 (P. no. 65). Content analysis for both the units is as follows.

Unit : I  Factorization of the type $a^2 - b^2$

Std. : IX
Age : 14+

Content analysis :

- Derivation of formula by inductive approach with the help of arithmetical illustrations.
- Explanation about factors of $a^2 - b^2$. 
- Examples based on the type $a^2 - b^2$
  - examples without coefficient $a^2$ and $b^2$
  - examples with coefficient of $a^2$ and no coefficient of $b^2$
  - examples with coefficient of $b^2$ and no coefficient of $a^2$
  - examples with coefficient of $a^2$ and $b^2$ both
- Examples of the type $x^4 - 16$ where further factorization is possible
- Examples of application type i.e. to find value of arithmetical problems.

Activities:
- Pupils are required to get the formula for factors of $a^2 - b^2$ using illustrations of arithmetic.
- Pupils are required to master the factors of $a^2 - b^2$ in generalised form.
- Pupils are required to get the factors of the type $a^2 - b^2$.
- Pupils are required to solve the problems when coefficients of $a^2$, coefficient of $b^2$ and coefficients of $a^2$ and $b^2$ both given.
- Pupils are required to apply their knowledge to compute the values of arithmetical problems.
Unit : II  Expansion of $(a + b)^2$

Std. : IX
Age : 14

Content analysis

- Derivation of formula for $(a + b)^2$ with the help of given figure using idea of area of square and rectangle.
- Derivation of same formula using method of expansion.
- Simple examples without coefficients of 'a' and 'b'.
- Derivation of formula for $(a - b)^2$ using formula for expansion of $(a + b)^2$.
- Difference in expansion of $(a + b)^2$ and $(a - b)^2$.
- Relation between three steps.
- Examples with coefficients of a and b.
- Computing values of given arithmetical problems.

Activities

- Pupils are required to derive formula for expansion of $(a + b)^2$ using idea of area of square and rectangle.
- Pupils are required to derive formula using method of expansion.
- Pupils are required to derive formula for expansion of $(a - b)^2$ using formula for expansion of $(a + b)^2$. 
Pupils are required to find out the expansion of examples with and without coefficients of a and b.
Pupils are required to apply their knowledge to compute the values of arithmetical problems.

3.6.5 Techniques used for programming

It was necessary to decide which programme style, response mode and presentation mode should be adopted before writing the frames for the programme; after describing and analysing the task.

(1) **Programme style**:

Programmed learning material developed in the present study has been of the linear style. In a linear programme a pupil has to pass through a carefully designed sequence of steps one after another; in a manner that makes learning cumulative throughout the whole sequence of frames. Linear programmes were developed because of its following chief features.

(i) Every learner follows the same path.

(ii) Programme is composed of small steps. Each frame is small and carries a single idea, example or rule.
(iii) Prompts or cues are given in the earlier frames to minimise probability of error and are, generally withdrawn towards the end.

(iv) Every pupil works at his own speed and follows the frame in the same order.

(v) Feedback or reinforcement is quick. Immediate knowledge of results acts as a reinforcement and maintains motivation.

(vi) Cheating is discouraged by not revealing the response until the learner has registered his response.

(vii) Response asked for requires a critical observation and comprehension.

(2) The response mode

The response mode is uniformly overt in nature. For each frame, irrespective of the type of the question. Pupils have to indicate answers in writing on the separate response sheet. In certain frames pupils have to select the correct answer from the alternatives given. After writing the response on a separate response sheet, pupils have to compare the response with the correct response provided in the programme. Pupils are allowed to proceed to study the next frame if response is correct, but if response is incorrect, either they have to follow
the previous or have to refer the specified frame or frames again and then to proceed to succeeding frame.

(3) Presentation mode

Many different types of format have been adopted in presenting the frames and correct responses in programmed learning material. In the present case, frames have been presented in between horizontal lines, and the correct response, to the question asked in a frame, is given in the margin adjoining the next frame on the left hand side. Pupils were provided with a thick rectangular paper slip for covering the correct responses. Pupils were also provided with a separate response sheet, in which frame numbers were specified and necessary space was provided for writing the responses. Pupils read each frame covering the correct response with the thick paper-slip provided, wrote their own response in the response sheet, and compared the response with the correct response provided in the programmed learning material.

(4) Writing frames

Construction of a programmed sequence and to write the frames is an important part in developing programmed learning material. In developing programmes
for the present study the sequence of the learning points was followed as per content analysis. The steps were kept as small as possible. Simple language was used. Care was taken not to include more than one learning point in a frame. The first draft of the programme was written, keeping in view, the entering behaviour and the terminal behaviour listed earlier. The specifications regarding the nature of the frames, and their sequence and presentation while writing the frames were also followed for the present programmes. The first draft of both the programmes, written separately, were edited by the investigator's guide, subject expert and programme expert from the point of view of subject matter and programming principles. Whenever need was felt, the frames were also discussed with the knowledgeable persons in the field of mathematics. Consequently, several modifications were made in the structure of the frames, as well as in their presentation sequence. The programmes were now ready for individual try out. Each frame was first written in 10 x 8 cms paper sheet, with the response at the back side of the paper sheet. Many frames in the programme consist of one or more sentences presenting some information. In some cases second component was instruction given to the pupils. Third component was in the form of a question.
It is indeed very essential, that the pupils must pass through a carefully designed sequence of steps. At the same time each step must be so small that it can always be solved correctly and doing so, pupils move further. Principle of very small step was followed while writing the frames for the present programmes. The present programmes include introductory frames, teaching frames, practice frames and review frames depending upon the sequential position they occupy in the behavioural change process. Prompts and cues are used in the frames whenever necessary. Different types of frames in the present programmes end with a question or questions. These questions are of the fill in the gaps type in many cases, in some cases alternatives are given and pupils have to select the correct response. It was on the basis of the suitability of a particular type of question, that the frame structure in each situation was decided upon, no specific rule was followed in this regard.

3.6.6 Evaluation and revision of the programmed learning material

A programmed material is a reproducible sequence of instructional events designed to produce a measurable and consistent effect on the behaviours of each acceptable pupil. Therefore, the investigator attempted
to arrive at an optimal sequence of the instructional events by trying it out on modifying it until a point was reached where there was empirical evidence to the effect that the programme was successful in imparting the intended instruction. Validation of the programmed learning material, prepared by the investigator, was divided into the following stages.

1. The individual student testing stage.
2. The field testing stage.
3. The final version of the programmes.

1. The individual student testing stage

Mullick and Dewal (1972) state that

"This stage mostly follows the finalisation of the first series of frames; including criterion frames in a programme. The methods of this stage tend to be clinical, in the sense that reliance is given to close observation or often interaction with a student individual" (P. 69).

The present investigator wanted to obtain feedback from his pupils from the very beginning and wanted to test each frame, word by word, till satisfaction about the effectiveness of each frame. Testing of the programme to get systematic answers to questions for
effectiveness was carried out for each frame. This testing programme requires judicious choice of pupils. In selecting the pupils care was taken to make representative sample of the target population. Nine pupils were selected from two gujarati medium schools of Anand town. They represented different ability levels. Out of nine pupils, three of them were above average, three were average and three of them were below average pupils.

The investigator sat with pupils who had prerequisite knowledge of concerned units; attending to only one at a time, and tried out all the frames. The investigator was in close contact with each pupil. Whenever pupils were confused, the frame was discussed with them to know the exact nature of difficulty. Another aspect of the frames that was checked during the individual try out; was regarding the language of the frames. The words; the meaning of which the pupils did not know, were noted down and further simplified. Some more information was provided in certain frames. Very simple language was used to avoid differences in the language ability which may not interfere in the process of learning. The pupils were informed to stop reading the next frame as soon as they felt tired. Thus programmes for both the units were thoroughly modified. The frames which were not responded well were reframed; resequenced and replaced.
by other frames. They were as follows (first draft of programme for both the units are given in appendix 5 and 6).

**Unit : I**

- Frame no. 4 was modified by giving one illustration.
- Frame no. 5 and 6 were combined to make only one frame with some modification.
- Frame no. 7 was divided into two frames.
- Frame no. 8 was totally dropped and instead of that one more frame was introduced for practice.
- Frame no. 9, 10 and 11 were totally replaced by newer frames as pupils were unable to understand through figures and were found complicated.
- After frame no. 11 one reading frame was introduced.
- Frame no. 12, 13 and 14 were also totally replaced by newer frames. These frames were dropped so as to get link with earlier frames. Frame no. 13 and 14 were introduced as practice frames.
- Frame no. 15 was modified by adding one illustration.
- Frame No. 16, 17 and 18 were kept as it is.
- Frame no. 19 was dropped as it was almost similar to frame no. 24.
- Frame no. 20 was modified by adding coefficient of c^2.
- Frame no. 21, 22 and 23 were dropped.
- Frame no. 24, 25, 27, 28, 29 and 30 were kept as it is but with change in number.
- Frame no. 26 was modified by changing the coefficient of $Z^2$ from 121 to 64.
- Frame no. 31 was dropped.
- Frame no. 32 was modified by providing more cues and prompts.
- Frame no. 33, 34, 35 and 36 were kept as it is but with change in number.

Unit: II

- In frame no. 3 figure was dropped and one illustration was added.
- In frame no. 4 figure was introduced and some additional information was dropped.
- Frame no. 5 was further divided into two frames.
- In frame no. 7 figure was introduced.
- Frame no. 8 was replaced by a new frame.
- Frame no. 9 was resequenced and given no. 15; but here some more responses were asked for.
- Frame no. 11 and 11 were dropped and newer frames were introduced.
- Frame no. 12 to 17 were resequenced from no. 19 to 24 in the final draft.
Frame no. 13, 14 and 15 were introduced.
Frame no. 16 was introduced.
The sequence of frame no. 18 was changed.
One more frame was introduced after that, to verify that the expansion by both the methods is equal.
Frame no. 19 was divided into some more frames. This gave rise to new frame nos. 25, 26, 27, 28 and 29 in final draft.
Frame no. 20, 21 and 22 were resequenced. Three more frames were added.
Frame no. 23 was dropped.
Frame no. 24, and 25 were further divided into frame no. 36, 37 and 38.
Frame no. 26 was dropped.
Frame no. 27, 28, 29, 30, 32 and 33 were resequenced.
Frame no. 31 was dropped.

2. The field testing stage

As a result of individual try out discussed in detail in the previous sub caption namely individual student testing stage, the programme had undergone certain major changes as indicated below.

The new draft for unit I has less frames and for unit II has more frames.
Many frames were resequenced.

Thus, the programmes were ready for field testing stage. Before giving for cyclostyling, the material was examined carefully by language expert and subject expert. Thirty pupils of standard IX from a local school of Anand town, were selected. The purpose of field testing was to improve the programmes so that pupils can respond to maximum frames. Modifications carried out during this stage are as below.

**Unit : I**

In the final draft of unit I,
- in frame no. 10 alternatives were added and pupils were asked to select the correct one.
- frame no. 26 was modified by giving hint in second step.

**Unit : II**

In the final draft of unit II,
- in frame no. 8 instruction was added.
- frame no. 42 was modified by giving more hints.

3. **Final version of the programmes**

With the above modifications, the programme on Unit I with 31 frames and Unit II with 45 frames were
ready for experiment and were cyclostyled (The final draft of the programme on unit I and unit II are given in appendix no. 7 and 9 respectively. Response sheets are also provided in appendix 8 and 10 for unit I and II, respectively).

3.6.7 Error rate

The programme should be constructed in such a way that the pupils can give correct response. When the pupil is actively engaged in responding to a frame overtly, it becomes possible to know how he learns. The percentages of errors could be worked out by knowing the number of wrong responses in each frame. From the percentages of errors, one can very well judge the quality and validity of the programme.

For the calculations of the error rate the investigator selected the following criteria.

1. An omission of the frame or the incorrect answer to the frame is to be considered as an error.
2. In the present programmes pupils have to make more than one response in several frames. Where pupils fail to respond correctly to one or more responses to particular frame, is to be considered as an error.
3. The error rate is to be considered on the basis of each frame as an unit.
For finding out the error rate, the random sample of 30 pupils from the local school of Anand was taken.

The error rate was found by using the following formula.

\[
\text{Error rate} = \frac{\text{Total error}}{\text{Total frames} \times \text{pupils}} \times 100
\]

The error rate thus obtained is shown in Table 3.1

<table>
<thead>
<tr>
<th>Table 3.1</th>
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</thead>
</table>

Error rate for programmes of unit I and Unit II

<table>
<thead>
<tr>
<th>Unit</th>
<th>No. of pupils</th>
<th>Total error</th>
<th>Total frames</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>30</td>
<td>68</td>
<td>31</td>
<td>7.31</td>
</tr>
<tr>
<td>II</td>
<td>30</td>
<td>90</td>
<td>45</td>
<td>6.66</td>
</tr>
</tbody>
</table>

Table 3.1 shows that error rate of both the units is very low. Error rate of unit I is 7.31 so, it can be said that pupils of standard IX were able to learn this unit with 92.69 per cent of success. Error rate of unit II is 6.66 so, it can be said that pupil
of standard IX were able to learn this unit with 93.34 per cent of success.

Thus, three instructional media for the experiment were prepared. The next chapter deals with planning of the experimental design.