

## **CHAPTER 5**

### **RESULTS AND DISCUSSION**

In this chapter the results and analysis of this study have been presented and discussed.

#### **5.1 ANALYSIS OF SCIENCE OBJECTIVES**

Content analysis of the science curricular documents for secondary level showed that at secondary level, the main objective of science education is the development of 'Scientific Literacy' (NCERT, 1990). This objective was found to be in consonance with the present curricular trends worldwide (Bybee, 1995, Cobern et al., 1995).

The stated objectives (NCERT, 1990) encompass all dimensions of scientific literacy

- (i) that the learners acquire scientific knowledge and understand the nature of science namely, the significance of drawing inferences through observation, study of cause and effect relations, formulation of hypothesis and their testing through experimentation;
- (ii) develop scientific attitudes and temper;
- (iii) develop instrumental, communication and problem solving skills; and,
- (iv) an increased awareness about one's environment in relation to science-technology- society (STS) issues.

This view of the multidimensional facets of scientific literacy has been supported by the curriculum developers in science (Lunnetta et al., 1984; Harms and Yager, 1984; Yager, 1993; and Hurd, 1998).

An objective of major significance set out in the curricular documents analysed was the one related to the development of open mindedness, intellectual honesty, courage to question, which would enable an individual to function in a science-technology based society. The objectives also emphasise the need for the learner to acquire process skills and indicate what the learners are expected to acquire after going through the learning process and 'completing some activities' (Walberg and Haertel, 1990) at the school. At the secondary level the learner is expected to build upon scientific knowledge acquired in the earlier grades. It is also expected that this knowledge would help the learners in interacting with their environment with a scientific attitude.

The stated objectives take into cognizance the fact that science curricula may not be restricted to passing on scientific knowledge (the teaching of scientific facts, concepts, principles and laws) alone (Harms and Yager, 1984), but also equip the learner with reasoning and problem solving skills which cut across all disciplines of knowledge. Practical work therefore forms a prominent feature of the present science curriculum. This is expected by the curricular framers to enable the learner to apply process skills in problem solving situations faced in daily life.

An important objective for the secondary school science curriculum is about developing sensitivity to the possible use and misuse of science, concern for clear environment and preservation of ecosystem. The rapid advancement in science and technology has brought to the forefront the question of social responsibility of science education (Ramsey, 1985; Yager, 1993). In this context, it has been considered that science education course should help the learners to critically evaluate the scientific knowledge especially about issues regarding science-technology - society interface (Lunetta et al., 1984; Bybee, 1997; Husen and Keeves, 1991), which directly affect the individual and society.

The need for 'science for all' for developing scientific temper and attitude also been stressed in the reports of all education commissions set up by the Government of India (IEC-1964-66, NPE-86) and this is reflected in the statement of curricular objectives.

Thus, an overall analysis of the stated objectives of the prescribed science curriculum under study (NCERT, 1990) shows that they have been formulated keeping in view the demands and needs of the subject matter, society (Armstrong, 1989) and the national aims as envisaged in the NPE-86 (revised 1992). However, it had been noted that they state only the curricular intentions in detail, but not the process of achieving the same which, if stated, would have got considerable positive influence on its full realization in actual classroom transaction in the

context of smooth transition from passing on 'scientific knowledge' to spreading of 'scientific literacy' in relation to STS issues which has a broader perspective.

## **5.2 CLASSROOM OBSERVATION: RESULTS AND ANALYSIS**

Results from classroom transactions in 240 classroom sessions observed by the investigator are described below.

### **5.2.1 Introduction of the Lesson / Concept Initiation :**

The manner of introduction of lesson is known to affect the response of the students (Chiapetta and Collette, 1984) to the instructional process (teaching - learning activity). A lesson can be introduced through a variety of methods like a demonstration of some experiment, display of a chart or a model, by summarizing the previous day's lesson, by asking questions on the previous lesson or by simply stating the topic. The manner of introduction of topics in the classroom sessions observed by the present investigator are summarised below:

**TABLE 1**  
**METHOD OF INTRODUCTION BY THE TEACHER**

METHOD OF INTRODUCTION	PERCENTAGE
Topic on black board or by simple statement OR Immediately begin (writing the topic on black-board and immediately begin teaching)	77
Question/Answer	20
Activity/ Demonstration	3

The classroom observation of 240 lessons in general science revealed that in 185 cases (77%) the lesson was introduced by simply writing the topic on the black board and recounting the previous day's lesson. Topics such as water, natural resources, conservation of energy, which can make use of students' knowledge and experience, were all introduced by simply stating the topic.

As an illustration, typical verbatim classroom transactions observed in a classroom are reproduced below:

### **Episode 1**

Teacher (T): The teacher wrote the topic 'rocks' on the black board. "Yesterday, I told you about the earth's crust and rocks. Today I will teach how rocks are formed".

## **Episode 2**

T : “Yesterday we saw that microbes are some times causing diseases. Today we will see how some diseases can be prevented”.

The next commonly observed method of initiating the lesson was by asking questions on previous day's lesson. This was observed in about 20% of the classes.

The questions seemed to have not been directed to elicit the extent of the students' understanding of the previous day's lesson.

This is illustrated below :

What is allotropy?

Define velocity.

What are the sources of vitamin A?

## **Episode 3**

T: Define allotropy.

S: Allotropy is the ability of carbon to exist in two forms.

T: Today I shall teach you about refining of petroleum.

## **Episode 4**

T: Who discovered the first cell?

S: Alexander Volta.

T: Today we shall see what are the differences between Voltaic and Daniell cells.

Another set of questions usually asked in the class room were of the form:

Can anyone tell me what I taught yesterday?

Can anyone tell me where I stopped?

Did you read the book/chapter?

Is there any doubt about yesterday's lesson?

Classroom observation showed that the following types of questions are used as a variation or as alternates:

Can anyone summarise what we did yesterday?

Can anyone tell me where did we end the lesson?

Did you follow what we did yesterday?

In these instances where these kinds of questions were used, the students' response was generally in the form of a chorus or in some cases, the teacher never waited for the students to respond but proceeded with the lesson. Some times, the teacher would answer the question and proceed with teaching the day's lesson. So, in such a classroom situation, it is difficult to gauge the extent of the grasp of previous lesson by the learners.

Another feature observed was that the teacher asked only those students who were ready to answer the questions, by raising their hand or by shouting out the answer.

The teachers never really made any attempt to find out whether majority of students had grasped the previous lesson /what had been taught earlier.

### **5.2.2 Lesson or Topic Introduced Through Activity, Demonstration**

In only three percent of the classes observed, the teachers began a lesson through demonstration / activity for introduction of topics. This is illustrated in the classroom example cited below:

#### **Episode 5**

The teacher brought two beakers A and B containing water and added some powder and stirred the solution. In one beaker lather was formed easily and in the other it did not. The teacher had instructed the students to observe the whole process carefully and came up with the following queries.

T: What do you observe?

S: In beaker B there is a lot of lather and in beaker A, there is very less of it.

T: The water, which does not give lather easily, is identified as hard-water.

Today we shall study about hardness of water.

#### **Episode 6**

In another situation, while teaching about magnetic effects of current (std. 9), the teacher introduced the topic through an activity. Students were asked to bring an electric wire and battery cells, bulb and a magnetic compass. The teacher instructed the students to connect the circuit and bring the compass needle near to the circuit. The students were asked to observe what was happening.

T: Connect the circuit as I am showing you here. (Teacher made the necessary



connections).

T: Have you made the circuit ready? Now look at what happens to the needle.

S (in chorus): It moves.

T: The needle moves because...

T: Today we shall talk of magnetic effects of current

In both these episodes, the teacher used demonstration / activity to initiate the lesson.

The questions and teacher-made statements at the opening of the lesson have been analysed to find out the nature of the introduction of a lesson. The time, as distributed in the classroom, was noted.

It was observed that, out of the 35 minutes allotted for the science period, 3-4 minutes were usually utilized for the teacher's need to move from one class to another. The time spent on introduction or initiation of the topic, on an average, was observed to be 3 minutes. Rest of the time was spent mostly in "teachers talk".

### **5.2.3 Influence of the Method of Introduction on Students' Response**

It was observed that, in general, the students were attentive to the proceedings in the classroom. However, in the instances where the lesson was introduced through activity, the students' response was more in terms of the number of the students ready to answer the teacher's questions about the activity.

It was also observed that the next day when the same teacher questioned about the previous day's lesson, which was based on activity, nearly 70% of the students showed eagerness to provide the answer. In the other classroom sessions however only 5-6% students showed their readiness to respond to the teachers questions.

#### **5.2.4 Teachers' Opinion Gathered About the Appropriate Introduction of the Lesson**

Teachers' opinion gathered about the appropriate introduction of the lesson indicated the following :

Ninety percent of the teachers under observation felt that for introduction of the lesson, it was sufficient to write the topic on the blackboard.

All the teachers agreed that an appropriate introduction to a lesson helped to capture pupils' attention to the task at hand.

Ninety percent of teachers indicated that they did not give elaborate introduction, as that would leave them very less amount of time for the actual lesson.

### **5.2.5 Method of Teaching (Mode of Classroom Teaching)**

A variety of methods are generally in vogue for teaching any subject matter. In the case of science, it can be considered that, the method most suitable would be the one, which conveys to the learner the nature of the subject matter. In teaching the subject of science, the nature of science needs to pervade (Smith et al., 1991, Rigden, 1991) all the instructional practices adopted.

Science teaching was observed in the classrooms in order to find out the most preferred method adopted by teachers for its dissemination and the reasons for their preference, and, the reasons why alternate methods are not being used even if they are recognized by them to be more suitable.

The observation of science classes in the present investigation indicated that

- (i) lecture method was used in 70% of cases,
- (ii) lecture cum discussion method in 10 percent,
- (iii) lecture-cum activity in 6% of the cases,
- (iv) non-conventional approaches in the remaining 14% of the classes observed.

In none of the classes under observation, problem solving method or inquiry based teaching had been done.

### 5.2.6 Lecture Method

This method was the one most widely used. Several teachers found this method most convenient to use and the teachers specified that large chunks of information could be conveyed in less amount of time. Interview with the teachers showed that especially for standard 9, the course was vast and lecture method was the most suitable. Also in most of the classrooms, the class strength varied in between 45-50 students which was also remarked upon by Chiapetta and Collette (1984). According to the teachers, with such class strength they would not find it convenient to use any other approach.

According to the teachers, Lecture method had generally been found suitable when trying to teach students **about concepts** such as, extraction of elements, introducing the properties and reactions of organic compounds, food preservation and management, atomic theory, classification of elements, energy changes and other scientific concepts.

However the present investigator noted from the classroom sessions that even topics which could easily be related to the students' daily life and experience were also taught through lecture method only. This is evident in the classroom situation cited below for illustration, where the teacher was transacting a lesson on water, its uses and chemical composition.

## **Episode 7**

T : You have all seen water. You can see it does not have any colour, it does not have any taste and it does not smell. When you take water in a glass tumbler you see the light passing through it. There are many sources of water- rivers, seas, lakes, ponds etc. The chemical formula of water is  $H_2O$ . (The teacher also wrote  $H_2O$  on the blackboard). Water can dissolve many things and is therefore a good solvent. Seawater contains many salts dissolved in it.

The teacher went on to describe the water cycle and characteristics of potable water. All the while, the students were not asked to participate, although the students could have discussed the water cycle, the properties of water etc. from their own earlier observations and experiences.

## **Episode 8**

The teacher was giving a lesson about useful plants and animals. The chapter in the textbook introduces the lesson by instructing the reader to look around and identify the sources of various things we use in daily life such as clothes, milk, woolen garments, shoes and rubber, paper, honey, sugar rice etc. The chapter goes on to describe the food producing plants, fibre producing, timber-yielding, medicinal and ornamental plants.

The classroom transaction for this topic was as follows:

T : Today we will study about useful plants and animals. So listen carefully

We get many things which, we use in daily life from plants and animals

For example, cow gives us milk, rice is from plants, honey from honeybees, fruits and vegetables. Grass is used to make paper. Even your leather shoes are obtained from animals. Silk is obtained from silk worms and cotton from cotton plants. So you can see plants and animals are very useful to us.

We can group the useful plants as (Written on black board):

1. Food producing
2. Fibres
3. Medicinal
4. Cash crops

The teacher went on to list the plant products such as cereals, pulses, the various vegetables and spices etc. The fibre producing plants such as cotton and jute were also listed.

T : The trees yield wood, which is used as a fuel. Wood is also used to make furniture. The trees whose wood is used to make furniture are deodar, pine and teak. Bamboo is used for construction of houses and also for making paper. There are many plants, which have medicinal value like, neem, amla etc. Similarly, the teacher without involving the student participation in

any manner also described the useful animals. Even the end-of-chapter questions and answers were read out and given by the teacher.

The above two examples are representatives of similar such classroom episodes observed. It is not to say that lecture method is to be discarded, but in introducing the type of topics mentioned above, it could perhaps be blended with students' participation through brief discussion depending on the nature of the topic.

In the investigator's opinion, for transaction of topics described above, lecture method combined judiciously with a brief interaction with students allows for taking into account the students' experience and knowledge and allows the scope for students' participation and creating interest in them.

However, as stated earlier, only in 10% of classes observed for this investigation, lecture cum discussion method was used. In such cases the teachers generated discussion on topics like necessity to protect trees, the *pros* and *cons* of constructing large dams. Some other issues the teacher raised and taught were the possible cause of plague. Some transactions are reproduced below:

## Episode 9

In this case the teacher was discussing the need to protect our environment. The teacher initiated the discussion as follows:

T: Last week we all celebrated the Makar Sankranti or Uttarayan as you call it. What all did you do?

S1: We flew kites.

S2: We burnt wood (Lori)

T: An important aspect of this festival is Lori. What kind of things did you burn?

S1: Some paper.

S2: In our locality, we collected wooden sticks from our houses and parks and our houses and burnt them.

S3: In my area some people cut the trees to get wood to burn.

T: What kind of trees were they, green or old dry trees?

S3: The branches, which were used for burning, were green.

T: Did they burn?

S: Not very well.

T: Why do we plant trees?

S1: They give us fresh air and shade.

S2: They give us fruits.

S3: They help in water remaining there (in the soil?).



T : These are all the uses of trees; what do you think would happen if the trees were cut down? Don't you think we are damaging/ spoiling the environment?

### **Episode 10**

In this case the topic being taught was 'Balanced diet'. The teacher invited the students to write what all they had eaten for breakfast, lunch and dinner and any other foodstuffs they had eaten. Once the students had written them on the blackboard and notebooks, the teacher asked them to identify the proteins, carbohydrates, fats, and vitamin-giving foodstuff in each of their meals.

A student had written that she had eaten rice, dal, spinach and curds for lunch, eggs for breakfast and chapatis for dinner. The student then identified the different elements of food. The teacher then asked the following set of questions:

T : Why do we eat a variety of foods for our meals? Why not eat rice and curds only?

S : Because to remain healthy, we need all foods to be eaten.

S : If we eat rice and curds only then we get carbohydrates and fats and no proteins and vitamins.

T : Why are proteins important?

S : Because they help in bodybuilding.

T : Do not carbohydrates do that?

S : They provide energy.

T : Anything else or any reason why we eat a variety of foodstuffs?

S : We need all kinds of foods to keep our body healthy.

T : Yes, and such a meal, is a balanced one.

The teacher and the students went on to discuss that what would happen if any of these elements were missing. The students had already read about the importance of a wholesome meal in their earlier classes (lower levels). So this teacher could involve the students in the discussions on “balanced diet”. At times, the same teacher resorted to lecture without discussion where she was explaining terms such as metabolism, defining terms like calorie, and calorific value, detailing out the role of proteins and carbohydrates etc., to explain the meaning or concepts.

In the examples highlighted above it was observed that in the first case, the students remained passive listeners and subsequent observation of that class by the present investigator indicated that the students rarely participated in the lesson in any other manner except in listening mode. The next day when the students were questioned on the previous day’s lesson most of them could not answer satisfactorily.

In the second case observed, the teacher created space for students’ participation. Also this teacher did not need to dictate or discuss the answers to the end-of-

chapter exercises. Also, the students' response to the questions and the discussion indicated that these students had a better grasp of the topic.

### **5.2.7 Teachers Perception Regarding Methods Used and Students' Response**

The investigator's follow up discussion with these particular teachers provided the following reasons for the methods used by them for lesson introduction. The teacher in the example 1 remarked that the topic on water was an easy one and so she did not want to lose time by involving students in developing the lesson. Also since the students were to appear in the board examinations it was important that course be completed quickly and revised.

In the second episode, the teacher remarked that students learnt better if the topics could be related to the previous knowledge. Also this teacher opined that all topics cannot involve elaborate discussions, but wherever possible it should be used. On questioning whether the teacher did not think that only a few students are vocal, this teacher remarked that she had evolved a system for herself that each time she would ask different students to respond.

The teacher in episode 9 had remarked that any other method led to lot of disciplinary problems. Also in large classrooms it was not convenient to have discussions. A lecture comprising of 'teacher talk' only would help controlling the class and also mean that all students listen to the teacher and there was no possibility of students taking down incorrect information. Also in a class where

there are 45 students, discussions may not prove very educative because even in discussions, only a few students would participate.

The teachers who used lecture cum discussion method (and did not conduct 'teacher talk' sessions) opined that generating discussion or involving students in the classroom helped the students to be able to express their opinion and exhibit their understanding of the various phenomena. Although initially only a few students might participate in these discussions, but a teacher can involve the other students also. These teachers did admit that they some times found themselves short of time. They also remarked that most of the topics could be dealt with in lecture mode as these involved elaborate explanations about scientific laws and concepts, and that there were only a few topics where students participation could be maximum.

And so, in the investigator's opinion, the time available in the classroom for teaching could be balanced by selecting the appropriate method depending on the topic.

#### **5.2.8 Activity Based Teaching**

As stated earlier, in some classes, the teacher used activity-based teaching. In such cases (6 percent), the teachers resorted to showing demonstrations or giving students some activity to work with. This method is discussed below.

## **Episode 11**

The teacher brought a piece of paper, some wax and magnesium wire and a piece of wood. The teacher burnt these substances and tried to convey to the students the idea about combustion and types of combustion.

## **Episode 12**

The teacher instructed the students to bring candles to the class. They were asked to light them and observe the zones of the flames and to write down their observations.

According to these teachers who used this method, this way of teaching helped the students to develop observation skills and in some cases critical thinking. For example, in the session where students had to write about the zones of the flame, the teacher posed them the question: “How does a candle burn?”

These teachers opined that using this method required adequate amount of time, space and preparation. Also only a few topics could be taught through this method.

In all the observations about teaching methodology done by the present investigator, it emerged that the majority of teachers used exclusively lecture method only sixteen percent of teachers used a combination of methods to teach.

### **5.2.9 Non-Conventional Methods of Teaching**

Some methods unusual to science teaching were also observed (14 percent) in the classroom transaction by the present investigator. This is illustrated in the following example:

#### **Episode 13**

The teacher was dealing with the chapter “food preservation and management”. The teacher instructed a student to start reading aloud from the textbook. After one paragraph, another student would read aloud for some time and this process went on for a major part of the period. Later, the teacher summarised whatever had been thus read-aloud as follows.

T: You have just seen that we have to maintain large amount of food since the food has to be supplied to all parts of the country. So food has been taken care of starting from planting of seed to harvesting and storing the food grains. And then you read how biotic i.e.; living factors and abiotic or non-living factors can spoil food. You also read about some methods of storage of grains. Now mark the answers for the question in the end of the chapter exercise.

## Episode 14

In another situation described here, the teacher was dealing the topic “pressure”. The teacher asked the student to read aloud a few paragraphs. The content in these paragraphs defines force, pressure and describes some experiments to indicate that liquids (p. 49-51 of the textbook) exert pressure. Once the reading aloud was done, the teacher ‘explained’ the same in Gujarati, by translating the content. Then the students were asked to read the next section.

## Episode 15

In this case, the teacher was transacting the topic on “Gravitation”. The teacher read aloud a few paragraphs from the text book (p. 83-85) and then explained the content as follows:

T: Whenever a body is falling down, a force acts on it and this is called gravitational force. This force causes a body to accelerate and this is called acceleration due to gravity. As you may have seen in the example that is read out, when you release a ball from say the 10th floor of a building,  $t = 0$  when the ball just starts falling. When the ball crosses 5th floor,  $t - t_1 = 7\text{s}$  and on hitting the ground  $t - t_2 = 10\text{s}$ . The height of the building is 20m. So on calculation it shows that the initial velocity of the ball is zero. And the ball covers the last 5 floors in 3 seconds and the first 5 floors in 7 seconds. So, is there any change in the ‘speed’ of the ball?

S1 : The ball was faster in the last five floors.

T : Yes, i.e., there is a change in velocity and we know change in velocity is acceleration.

T : On the earth there is gravity and therefore things fall back on being thrown up in air. Newton discovered that any two objects in this universe attract each other. This force is called gravitation.

At this point, the teacher instructed the students to read these pages again silently. They were then instructed to 'shut' their textbooks and the teacher put the following question.

T : What is force of attraction between any two objects called?

S : Gravitation (answers with the help of textbook)

T : How do you know that a body has acceleration while falling down?  
Describe the experiment.

The students after referring again to the textbook read out the relevant portions of the answer. After this, the teacher proceeded to read the next few paragraphs and the whole procedure was repeated.

In the lesson follow up discussion with the investigator, the teachers using these non-conventional methods justified that these methods were useful as one could make sure that the students would read the textbooks. And also the teacher can proceed to 'teach' systematically (as the textbook has given the content). Also



there was no possibility for the students to complain that any portion of the textbook had been left out without teaching in the classroom.

From the above, the following points emerge about the nature of actual classroom transactions in the schools under observation:

The teachers use Lecture Method most of time.

Theoretical and other scientific concepts are predominantly taught through lecture method.

A few teachers use some activities in the class or demonstrate some of the phenomena.

Some teachers use lecture-cum-discussion method for such topics with which the students are familiar to some extent, or those topics, which relate to their daily experience.

Some teachers believe that students need to memorize facts from textbook as given, hence read aloud method is used.

In majority of cases, 'teachers-talk' predominates say for 26 out of 35 minutes -- taking a major part of the period without students' participation.

In general, the teachers indicated that since there are so many concepts etc., for which explanations have to be detailed, they found the text book sometimes inadequate and resorted to lecture method. Another contention was that only a few students take part in discussion. Also the teachers feel that it would be difficult to

ascertain whether majority of the class understands the teaching point, as students' ability to be able to assimilate the points emerging from discussion is doubtful. Teachers did not think it necessary that demonstrations etc. should be used always as then the students would never learn to think about abstract concepts.

Some teachers are of the opinion that they used problem-solving method to teach science and accordingly they solved the numerical problems on the black board. According to these teachers, problem-solving method meant 'solving numerical problems'. It may be recalled that problem solving meant (Ausubel, 1968), seeking solution by the learners to a problem through transformation of information by analysis, synthesis, hypothesis formulation and testing and acquiring these process skills.

All the teachers in principle agreed that science should be taught by 'doing' but doing only the specified list of experiments, which can be taken care of during the very limited time available for a practical class.

In the secondary schools at Vadodara, every week on one day, there is a 'double period' for allowing the teachers to conduct experiments etc. However, the present investigator noticed that mostly this is utilized for other purposes such as correcting note books, dictating answers to end-of-chapter exercises or teaching other subjects for completion of course work.

Science projects and laboratory work are considered by some of the teachers to be separate from classroom teaching.

With time constraint of 35 minutes, teachers did not think that discussions could be conducted.

#### **5.2.10 Language Style Used By The Teacher**

In all the classes, the language style used by the teacher was the language in which the textbook has been written. Not many attempts are usually made by the teachers in simplifying the language to make it easily comprehensible to the students. This is illustrated in the following example of the classroom transaction observed by the present investigator.

#### **Episode 16**

While teaching about reflection and refraction of light:

T : Let me tell you about reflection of light. It happens when light rays fall on a surface like mirror and rebound. In the case of refraction of light, the rays pass through different media and bending of light ray takes place.

T : What is reflection of light?

There was no response from the students to this question. Instead, if the teacher could have used a simpler language i.e., instructed that when rays of light fall on a shiny smooth surface they just come back in the opposite direction and indicated

it through a simple diagram, it would have been more easily comprehended. Similarly the teacher need to have differentiated between the phenomena of reflection and refraction, defined and explained the terms such as 'medium', 'bending of light' and so on. Repeating whatever had been given in the textbook itself, in the investigator's view, does not constitute an explanation that could be easily understood by the students.

### **5.2.11 Teaching Aids**

In the classes observed for the present investigation, only in ten percent of cases, teachers were found using teaching aids like models, charts. In most of the classes (ninety-percent cases) the teachers made use of only the black board. The schools were equipped with charts depicting the various processes like extraction of metals, life processes, atomic structure, periodic table etc. Though models were not extensively available in the schools (except in 3 out of 16 schools under observation), simpler models like ball and stick were generally available to aid teaching of topics related to chemistry.

A few classroom transactions on this aspect observed in different schools are reproduced below:

#### **Episode 17**

One teacher, during the teaching of formation of igneous rocks and soil profile, instructed the students to look into the textbook as he explained (read out from the

book) about the process.

### **Episode 18**

In the case of a lesson on formation of images by convex lens, the teacher instructed the students to refer to the diagrams in the textbook.

### **Episode 19**

A teacher, explaining about plant and animal cells, taught the same without even drawing a diagram on the black board and although available, the charts were not used as teaching aids.

In all such cases, in the schools under observation, when queried why teaching aids were not being used in the classroom, the teachers replied that their schools did not lack in charts, but models were not freely available. The teachers did not quote any specific reason for not using the teaching aids except to say that most of the diagrams are already contained in the text book also and whenever required, they could readily refer the students to the text book.

One may concede that it is not possible or essential that for all topics, teaching should be supplemented by using models e.g. universal laws of gravitation, velocity (motion), biosphere, habitat etc. But certainly there were many topics in the curriculum while teaching which, visual aids could have been used in making the students understand the concept involved. In this context, the differences in

student response to two classroom transactions observed in the present investigation and reproduced below are very illustrative.

### **Episode 20**

Teaching about electric motor, magnetism:

One of the classes observed was where the teacher was dealing about the properties of magnets, the two poles of magnet, free suspension of a magnet and magnetic lines of force. The teacher gave a verbal explanation that a magnet has two poles and that magnetic lines of force emerge from the North Pole and move towards the South Pole.

The students came up with questions like, do lines of force exist all around the magnet, how can one find the north or South Pole of a magnet etc., which the teacher clarified orally. But in this situation, the teacher had to keep-on clearing doubts of the students orally for giving all the information. Demonstration of a chart, or a model to depict the magnetic properties would have saved time and enhanced the students understanding.

### **Episode 21**

In this instance interestingly the teacher taught about magnetism as follows. The class was divided into groups and each group was given a set of magnets and iron filings for performing an experiment and notes their observations. In this situation, the students observed on their own, what happens when a magnet is suspended,

how lines of force are formed and so on. So at the end of these, all the teacher had to do was to summarize what all they had observed. Such an approach obviously leaves some minutes for teacher-learner interaction in contrast to Episode 20 where more time was spent on oral clarification by the teacher.

#### **5.2.12 Explanation of Concepts**

While transacting the various phenomena in science in the classroom, the attempt by the teacher should be at explaining the how, why and what of the scientific concept /observation. A major part of teaching involves providing explanations about the various scientific phenomenon observed. During explaining such concepts, the teachers may have to use examples to make the point clear. The examples chosen play an important role in enhancing students' understanding and comprehension.

Examples can also be drawn from daily life to explain or explanations can be based on the previous knowledge of the learner or explanations can be based on hypothesising and proving or disproving the same.

The different patterns noticed in providing 'Explanation of concepts' in actual practice in the classrooms are described below with a few examples taken from the classroom situations observed during the present investigation.

- (1) In ten percent of the classes observed, the teachers read out or would ask the students to read out and simply translate the content into the vernacular

language and considered that they had ‘explained’ the concept/topic etc.

- (2) In eighty percent of the classes observed, scientific concepts were passed on more like ‘information’ without much explanation. To quote an example, this is how the transaction took place in a classroom under observation. The teacher was dealing with the topic on various models of atomic structure.

## **Episode 22**

T : The earliest model was proposed by Dalton, who said matter comprises of atoms, and the elements consist of one kind of atoms. The next model was proposed by Rutherford who bombarded a gold foil with alpha particles and found out that atoms comprise of nucleus, protons in nucleus and electrons around the nucleus. Later on, neutron was discovered. Bohr first described a hydrogen atom and proposed that neutrons and protons reside in the nucleus and electrons circle around the nucleus in definite paths called orbits.

In the above classroom transaction, it can be easily seen that here, the teacher could have briefly given an idea about nature of scientific knowledge: that it is tentative and therefore a dynamic body of information. Also it was necessary for students to be aware why Dalton’s proposition about the composition of an atom had to be modified and why Rutherford’s model although provides a lot of information about the structure of atom, still could not completely be accepted.



Also the significance of Rutherford's experiment which shows that a scientist, based on certain hypothesis and previous knowledge, sets out further to understand the phenomena involved (in this case, the atomic structure) by setting up and performing an experiment, and recording observations and then appropriately interpreting the recorded data. This would give the learners an idea of a scientific process involved in furthering knowledge.

- (3) However, in another ten percent of classes observed in this study, the explanation of concepts was done through participatory approach. Here the clarification of concept was sought through generation of questions or through activity and otherwise or through generating hypotheses and giving alternate explanations and then arriving at the most acceptable explanation.

### **Episode 23**

In teaching about the necessity to conserve the trees, the teacher posed a question as what would happen if there were no trees. In this situation, the students came up with some ideas and these were discussed and finally the teacher summarized by indicating the need to protect the trees.

### **Episode 24**

While teaching about mass and weight, the students were posed with the problem about what would spring balance read at the Poles, and at the Equator. The students hypothesised about whether the readings would be equal or not and if

they are not equal, what factors could cause the reading to be different.

On analysing the 'explanation' transacted to the students by the teachers under observation in this investigation, the following points emerge:

It may be inferred that teachers generally confined themselves to 'explaining' only to the extent that the textbooks give information. This has been the general pattern of 'explanation' of scientific concepts in most of the schools (90%) observed.

To some extent, the approach practiced in 10% of cases as shown in example 3 cited above, seems to meet the orientation given by Yashpal Committee recommendations on teaching science at secondary level.

### **5.2.13 Subject Matter**

As in the case of explanation of concepts, the subject matter content taught in 90% of the cases was limited to the textbook. In only 10% of the cases observed, the teachers used other reference material. The teachers opine that since questions in the examination are textbook based they (the learners) did not require other reference material.

The teachers did not see any need to supplement the subject matter already given in textbook with additional information to suit the student's immediate environment or interests of the learner. This was because whatever subject matter exists in the textbook has to be taught in the classroom. And the subject matter in science is quite factual so there is no possibility of modifying facts.

The teachers considered topics such as man, science and technology, Natural wealth, Alternative sources of energy, energy crisis etc., not so important from the explanation point of view. They did agree that in these topics, the subject matter could be related to the students' environment. Since these topics are too general and are informative even if read by the students on their own from the textbook, they did not spend much time on them.

The reason cited by the teachers (assessed through personal discussion with them) was that they felt that the content in the textbook was quite adequate and there was no necessity to provide more content from other sources.

In standard 9 and 8 there was a lot of theory which has to be taught and hence the teachers tend to keep the explanations very textbook like. According to them, text book content had several gaps and therefore the teachers being unsure about what has not been given in the text book should be taught or not, stuck to whatever material is contained in the text book and nothing more. Also they feel that in some chapters the textbook content was not well organised hence sometimes the explanations were inadequate. The examples cited by them were as follows:

e.g. standard 9: sources of energy, heat, effects of electricity

The teachers also expressed a view that scientific knowledge is quite factual and facts may change in course of time; but still the facts mentioned in the textbook currently being used were clear cut and did not need much explanation.

Secondly the course to be covered (read content) is quite vast, hence there is not much scope to include reference material. Teachers agreed that some reference material might be useful for topics such as biosphere, alternate sources of energy etc., but they did not use any, as reference material was not readily available.

#### **5.2.14 Participation by the Students**

Learners' interaction with the teachers and their participation in the classroom session was observed.

The results are:

- (1) In 80 percent of the classes observed the student participated only as a passive listener. In a period of 35 minutes the teacher talk lasted for 26-28 minutes. The students' participation, if any, was limited to seeking clarification on the teaching point.

According to the teachers of these classes, most of the content was such that it was more convenient that the teacher explain everything. So in most of the classrooms the teacher acts as a source of knowledge.

The teachers also felt that ultimately when it comes to examination, the students are expected to reproduce some sections of scientific information contained in the textbook, hence they did not see the essentiality of conducting discussion sessions or participative sessions.

- (2) In fourteen per cent of the classes, the student participation was through involvement in reading aloud from the textbooks.
- (3) In the rest of the classes (6 percent), the students actively participated in the development of lesson by quoting examples, performing the activities designed by the teacher, by posing questions, bringing in relevant information.

In the classrooms where students participated actively, the teachers made it possible by adopting lecture cum discussion or activity or demonstration based teaching strategy. In such cases the teacher-talk to student-talk is fairly evenly distributed (14-16 minutes).

The teachers who used a participatory approach however admitted that the participants among the students are a few, as most of them tend to keep quiet. In these classes observed, in four percent of the cases the teachers were seen to conduct the discussions with only a selected few students. In only 2% of the classes the teachers were making an effort to involve maximum number of students.

#### **5.2.15 New and Unfamiliar Terms**

In the classroom observations made it was noticed that new and unfamiliar terms were introduced during the instructional process. In most of the cases, the teachers did not prepare the students for understanding those terms; the unfamiliar terms

were written on the black board and repeated.

#### **5.2.16 Nature of Questions Asked by the Teacher in the Classroom**

Questions asked can be of recall and recognition kind (simplest), application level, analytical kind (Smith et al., 1993) or evaluative (complex). In the light of this, the questions asked by the teachers during the classroom observation were analysed. The analysis in the present study indicates that overall, the questions asked number about 3-4 in a class-size of 30 - 40 students. As mentioned earlier, most of the time, the teacher used the lecture mode to teach without asking any questions.

Questions put to the students were generally for them to recall some information taught in the previous classes. These questions, in several cases were usually utilised by the teacher to initiate or close the day's lesson.

The other type of questions which were asked by the teachers in the few cases observed in the classroom, were to elicit whether the students had understood the teaching point.

#### **Episode 24**

Could you tell me what all I taught today?

Give the different food components of a balanced diet.

Name two water borne and air borne diseases each.

It is evident that these kinds of questions (recall type) were sometimes used by the teachers to end the lesson. The response to these questions is only indicative whether the students were attentive to the teacher or not. If the teacher could leave some 5 minutes at the end of the class to summarise the lesson, the teacher can find out to what extent the students understood the lesson by asking higher level questions, instead of confining to only simple and recall type of questions.

For example, a question “What are the different food components of a balanced diet?” can be followed up with another question where the teacher writes 3-4 groups of food stuffs and asks the students to identify that group of food, which would constitute a balanced meal.

There were very few instances where teachers used probing questions. Those teachers (6%) who employed lecture-cum-discussion/demonstration used these questions or activity based teaching. To cite an example, one such classroom transaction was as follows:

### **Episode 25**

The teacher was deliberating about energy changes in chemical reactions, took 2 test tubes and added  $\text{CaCl}_2$  to one and sodium hydroxide to the other. And then, added water to both the test tubes. The teacher then asked the students to feel the test tubes and came up with the following questions to the class:

What is the difference between the two test tubes when you touched them?

What do you think must have happened so that one test tube was warm to touch and the other one cool?

Some other probing type of question of higher order (though such instances were very few) come across by the present investigator during class room observations was:

Keeping in mind the conditions existing in the desert what kind of modifications do you think will a plant need for its survival?

This type of question helps the students to evaluate/ identify the desert conditions in terms of temperature, availability of water etc., and then work out how a plant can survive in a desert.

These kinds of questions allow a student to use previous knowledge, to analyse the given situation, to examine various kinds of propositions-answers and then arrive at the most plausible conclusion for finding an appropriate answer (Carlsen, 1991).

#### **5.2.17 Nature of Questions Faced by Teachers in the Classroom**

In any instructional process, the teacher-student interaction is expected to comprise of exchange of information, sharing of ideas, questions faced by the teacher and questions from students. The questions posed by the students may be for seeking clarification on a teaching point, could be related to the lesson taught



and based on the students' observation. Some times it could be a query to know more about some phenomenon which may or may not be connected to the lesson directly.

There were very few instances (3%) where student's participation in the lesson was through probing questions. An example is cited below:

### **Episode 26**

The discussion in the classroom was about circulatory system in human body where the discussion centred around question raised by a student about how blood moves only in one direction and what would happen if it moves in both directions. In this case the teacher and students spent time exploring this point. It was observed that in the next day's class some students had brought explanation read by them from other books as they found textbook content limited in its explanation.

In the instructional process when a teacher poses a problem or a question, the students may respond in any of the following ways: by giving

- (i) correct response
- (ii) partially correct response
- (iii) incorrect response
- (iv) add some more information or
- (v) by keeping silent.

As already noted earlier, in most of the classes the method used for teaching was the lecture method and questions asked by the teacher were rare.

In ninety percent of cases, the teachers after posing the question did not pause to give some time to the students to respond. The teacher would proceed to provide the answer also immediately after asking the question. In the few cases where the students gave correct answers it was observed that this happened when the teacher kept the level of questions simple:

### **Episode 27**

e.g.: What are the two allotropes of carbon?

What is the name of the process by which petrol is obtained from crude oil?

The students came out with partially correct responses; in 90% of the cases, the teacher would give the right answer and proceed with the lesson. The teacher would not indicate to what extent the student had been correct. Also the teacher would ask only one student to respond and generally the question would be addressed to a student who signaled that he/she knew the answer, but not at random in the class.

### **Episode 28**

The teacher was dealing with the topic about the change of state and asked the following question after teaching about boiling point.

T : Why does water boil quickly on mountaintops?

Out of 40 students in the class, only 3 of them indicated that they would answer.

The teacher asked one of them to answer.

S: Because as we go up, the pressure decreases. So water will reach the boiling temperature quickly i.e. 100 degrees Celsius.

In this case the student is partially correct when the student says pressure decreases when one goes high up on mountain but does not realise that there water boils at a temperature lower than 100 degrees C.

This was an application level of question where the students had to use their information previously received about boiling point. Once the student answered as recorded above, the teacher responded as follows:

T: No that is not the correct answer. When you are high on mountains the boiling point of water decreases because of lowering of atmospheric pressure.

#### **5.2.18 Reference to Additional Source Material**

In the instructional process a teacher cannot be a complete source of information, nor the textbook can be. Many a time some other material may have to be referred to. The purpose of reference can be to acquire more information about some phenomenon, understanding some concept, for solving some problems and so on

The classroom observation by the present investigator showed that in 90% of the classes, the teachers did not refer the students to other materials. The teachers put forth whatever information is there in the textbooks and since in the classroom, teacher-talk prevails, there is not much scope for the teacher to even consider using some reference material. During the interviews it was found that according to the teachers, the textbook was sufficient and since the students would have to give examination based on the textbook material, they did not lay much emphasis on using any other reference material.

There was no instance during the classroom observations in the present investigation where any reference material was suggested to the students even on occasions where the teacher or textbook could not provide complete information. This situation is rather disturbing and needs to be remedied. This point is illustrated by one such classroom transaction given below.

### **Episode 29**

The teacher was dealing with a lesson (standard 8) about using fertilizers to increase the productivity of agriculture food crops. The teacher went on to name a few chemical fertilizers. One student however put forth the following question.

S : I have read that chemical fertilizers are not good and therefore should not be used.

T : Who told you that chemical fertilizers are not good? Don't you see so many

advertisements, which tell farmers to use NPK etc? Chemical fertilizers have to be used to increase the production of food crops.

S : Then why was it written that chemicals should not be used.

At this point, the teacher's answer was, “why don’t you read the textbook? If you don’t write the way the textbook gives, you will not get marks”

In standard 10, the textbook does mention that compost fertilizers are to be used and that chemical fertilizers need to be used very carefully.

This example clearly brings out the importance given to the material in the textbook. Questions set for the examination and answers expected from the learners in general are oriented towards almost a direct verbatim reproduction of the text book material and in several cases, not “application oriented”. In most cases, the questions do not call for an effort from the learner to apply the principles or concepts underlying the lesson in the textbook.

In this particular instance, instead of the above quoted response, the teacher could perhaps have directed the student to see the 10th standard textbook and also list out a few sources as reference for the student to find out more about the use of chemical fertilizers which could have provided useful information.

### **5.2.19 Summarisation of Lesson**

A teacher needs to complete the teaching of a lesson by summarizing the lesson, so that the students are able to see the links between the different concepts taught on that day.

Recapitulating the important points, by asking probing questions can do summarizing the lesson or simply closing the lesson as time runs out.

In 90% of the cases of classroom observation, the teachers ended the lesson, as the time for the class would get over. So the teacher was never left with any time for summarizing the lesson.

In ten percent of cases the teachers ended the lesson by asking one or two questions. But even then, the teachers did not wait for the students to respond; instead, would tell them to read the lesson before coming to the class next time.

### **5.2.20 Assignments**

Assignments form an inherent part of the instructional process as these can be used to find out the understanding gained by the students about scientific concepts, their ability to apply them. Assignments can also be one way of assessing the students. Most of the time the teachers did not give any special assignment.

In ninety percent of cases, the assignments were based on end-of-chapter exercise. Such assignments were also of two kinds

- i) Where a teacher would give the answers verbally or get them marked in the textbook and ask the students to write them.
- ii) Where teachers dictated the answers in the class and the students were asked to rewrite them in Home Work note books.

### **Episode 30**

In ten percent of cases the students were given assignments mentioned below with a difference in approach.

On the topic on Optics:

“To identify the lenses and mirrors used in our daily life” along with the purpose.

### **Episode 31**

On the topic: Conservation of water, an assignment entitled

“How much water do you use daily?”

### **Episode 32**

On the topic: Forests of India,

"Take a physical map of India and identify the forest regions. In another map identify the different 'Project Tiger' centres".

Evidently, some of these assignments provide opportunity to the students to refer to some other material apart from the textbook. In some cases the assignments can also enhance the understanding for the students. E.g. they were instructed to take up one disease caused by microorganisms and then find out the cause and methods of their prevention.

The teachers who were giving textbook centred assignments (end of chapter exercises) opined that the students need to know the answers of the text book questions well, as during the examinations they would be asked questions on the text book material. Also if the students were to be given some other assignment then only 3 to 4 students would actually look for information and the others would simply copy the answers. In such a case it is not useful to give such assignments.

In the lower classes the students are used to answers being dictated to them, hence, the students are unable to write the answers on their own.

Also it makes the checking of notebooks easy if answers are dictated.

#### **5.2.21 Laboratory Work**

Laboratory work is an essential part of science education. Science is one of those disciplines where learning by doing is the most essential process.

In all the schools, a double period is allotted every week in science for practical work. But in most of the schools, this time is not used for the purposes intended.

Of the 16 schools under the investigator's observation, only in three schools,



regular laboratory work was organized for students. Laboratory work could thus be observed only in 15 out of 240 classes observed. In all these cases, a double period was allotted for practical work in science.

In the other schools the double period is used for correcting the notebooks (one period) and one for teaching backlog if any. Sometimes the teacher uses the double period for dictating answers to the end-of-chapter exercises in the textbook.

Laboratory work can be organized in different ways.

- (i) Where the experiment is demonstrated and the students are asked to follow it.
- (ii) Students work individually or in groups
- (iii) The theory is discussed and students asked to design experiment and to verify it.

In the observations made in the present study, the laboratory work organized was of the kind where experiment is demonstrated and the students asked to follow it. Given below is an example of such a class room transaction.

### **Episode 33**

The students were shown how to find out the resultant of two forces by the parallelogram of forces method. They were instructed to observe what the teacher was doing and later told to replicate it. In this also the students worked in groups of four. So all the students did not individually get a chance to do the experiment.

This experiment was done by the student-groups even before they were taught the lesson on vectors.

These kinds of practical work which are based on verifying the scientific laws, if done along with theoretical aspect, can enhance the students' understanding. But the above-described situation indicates that the practical work is done as an activity without much understanding, disconnected in time with the theory behind it.

Laboratory work can also help the students to examine different kinds of specimens which are otherwise not readily /visually observed like — microorganisms or some plant species which grow in specific habitats.

### **Episode 34**

The teacher utilized the laboratory period for supplementing her teaching by showing the students the mounted specimens of microorganisms. The teacher pointed out the distinguishing features of the microorganisms. However the only drawback of this practical session observed was that the teacher, after allowing the students to observe the specimen, (through the microscope), instructed them to copy the diagrams of the microorganisms in their records from the textbook and not from what they directly observed in the experiment.

Laboratory work is organised for standard 9 students only. The teachers informed that, for class 8 and 10, no list of experiments has been supplied. So, no regular practical work was organised for them. And the teachers generally did not organise the practicals as no board examination in practical work was to be conducted. So they did not think it important to conduct the practical classes.

The teachers stated that they did not find any lack of material sources. However, they did not feel that time was sufficient to conduct practical work regularly as that may mean that the teachers may not find time for correcting the notebooks or dictating answers to the end-of-the chapter questions, for which, as already mentioned, they sometimes utilize the double period.

From the above, it can be inferred that either due to lack of time, or since there are no prescribed practical examination at the secondary level, not much attention is paid in a majority of schools for conducting practicals or demonstrating experiments in standards 8th and 10th.

### **5.3 RESULTS FROM THE QUESTIONNAIRE**

The questionnaire was distributed in 100 schools of Vadodara of which teachers from 46 schools responded. The number of teachers who filled up the questionnaire was 120.

### **5.3.1 Section I : Teacher Profile**

This refers to the educational qualifications of the teachers and their professional experience, grades engaged, and subjects taught and any in-service programmes attended by them in the last five years.

#### **Educational Qualifications**

Seventy percent of the teachers were graduates, and the rest were post-graduates.

All the teachers are qualified B. Ed. degree holders.

#### **Teaching Experience**

The teaching experience ranged from <5 years to >20 years. All the teachers were engaged in teaching science at the secondary level, grades 8,9 and 10.

#### **Additional Subjects**

Although they were primarily science teachers some of them were assigned teaching duty in other subjects also.

**TABLE 2**

**ADDITIONAL SUBJECTS TAUGHT**

SUBJECTS TAUGHT	PERCENTAGE OF TEACHERS
Languages ( English )	60
Mathematics	20

**Number of Periods Taught**

On a weekly basis all teachers engage a minimum of 40 periods and a maximum of 42.

**In-service Training Programme**

Seventy percent of the teachers who responded to the questionnaire had not attended any in-service training programme. The rest 30% had attended a meeting organized by some schools at Vadodara before the implementation of the new textbook.

**5.3.2 Section II : Objectives of Teaching Science (Teachers' Response)**

Eighty three percent of the teachers indicated that the objectives of teaching science (what is required to be developed in a learner through a science education programme) were precise. Rest seventeen percent of the teachers felt these statements seemed more like general aims and were not clear to them as to how the expectations could be fulfilled.

During the follow up interview on the questionnaire these teachers (17%) said that one of the objectives is to develop scientific temper but how it was to be developed had not been stated. They further added that certain statements were very precise such as: develop concern for clean environment, preservation of ecosystem, develop courage to question. However, statements like cultivating social, moral, ethical aesthetic values which exalt the life of an individual and society are not clear to them.

### 5.3.2.1 Dimension of Scientific Literacy

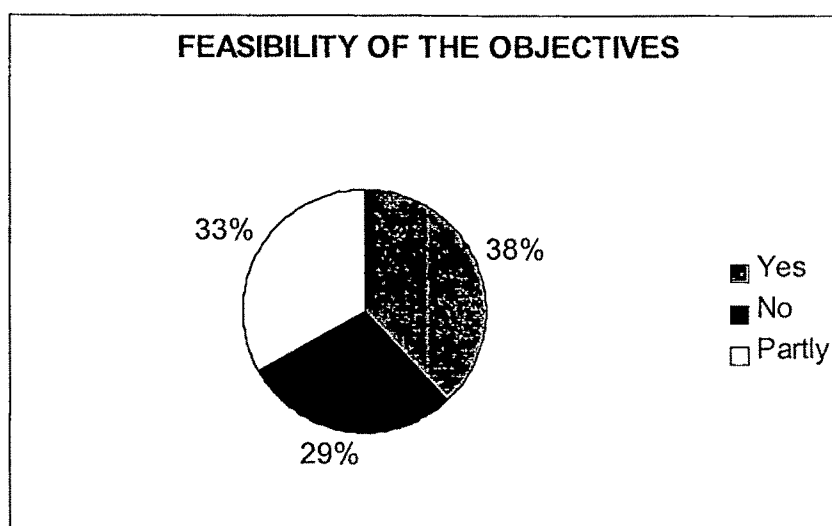
The teachers were asked to respond on what they understood of scientific literacy.

**TABLE 3**  
**TEACHERS’ UNDERSTANDING OF SCIENTIFIC LITERACY**

STATEMENT ABOUT SCIENTIFIC LITERACY	PERCENTAGE OF TEACHERS
Acquiring scientific knowledge	100
Applying scientific knowledge	15
Understanding societal issues	5

### 5.3.2.2 Feasibility of Objectives of Teaching Science

The opinion of the teachers about the feasibility of the objectives (Fig.3) was that they are feasible (38%) and partly feasible (33%).



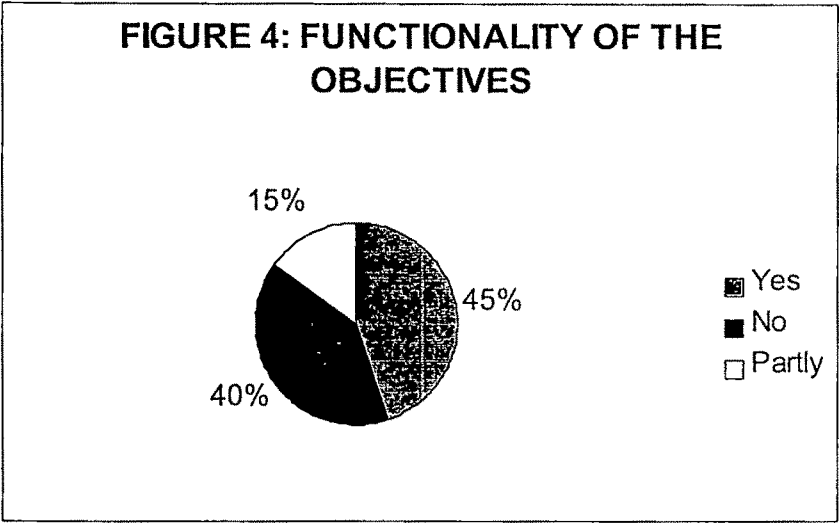
During the follow up interview, twenty nine of teachers opined that objectives are not feasible as they felt more time would be required. Also they were of the opinion that science at the secondary level, is just one among other subjects and many students may discontinue with science. Hence the students just learn some "science content".

Another reason quoted by them was that the content in the textbook does not consider the development of problem solving skills, scientific temper, and, cultivation of social, moral and aesthetic values.

Thirty three per cent of teachers opined that objectives 1,5,6 and 7 (Appendix 4) are feasible as the textbook supports these also. But the rest of the objectives (moral, ethical etc.,) are less feasible as specific guidelines are not available in the textbook content.

**5.3.2.3 Functionality of the Objectives**

Opinion of teachers whether objectives are directed in systematising and organising the instructional activities was as follows:



Opinion regarding the functionality of objectives was nearly equally divided (Fig. 4) among the teachers. Forty five percent of them feel they are functional. Forty percent have a different opinion that they are not functional, while 15% of them feel that they are partly functional. These teachers in the follow up interview clarified that that objectives such as developing communication skill, scientific attitudes and temper, moral and aesthetic values need to be supported by directions about how to achieve or develop these.



### **5.3.3 Section III : Textbook Content**

The teachers opinion regarding text books is given in the following section

#### **5.3.3.1 Relevance of Textbook Content to Objectives of Teaching Science**

The teacher's opinion revealed that seventy percent of them found the content to be relevant to the objectives of science. The rest did not agree with this. The follow up discussion also revealed that according to them (30%), the content reflected the objective pertaining to developing and understanding of scientific concepts and laws, but it does not reflect other objectives such as developing scientific attitude and values, information about the historical development of science, relation between science and society, and neither does it help in undertaking any vocation or profession at this stage.

#### **5.3.3.2 Factual Errors In The Textbook**

A majority of teachers stated that there were no factual errors. All of them agreed that the content was upto date.

#### **5.3.3.3 Presentation Of Content**

Opinion was sought about presentation of content with regards to suitability to learners' ability to interact with the content. The data obtained was as follows:

**TABLE 4****TEACHERS OPINION ABOUT THE PRESENTATION OF CONTENT**

Item	Percent		
	Yes	No	Partly
Content easily understood by the learner	53	47	-
Suitability to those who may study science further	3	97	-
Suitability to those who may not study science further	100	-	-
Examples related to learner's daily life	53	47	-
Arouse learner's curiosity for alternate sources	3	91	6
Coherent with syllabus	100	-	-
Appropriateness of language (simple and easily comprehended )	70	30	-

Follow up interview showed that the explanations in the textbook require improvement to enhance students' understanding. All teachers agreed that this course is suitable for those who may not study science further, since the content deals with such topics like health, hygiene, balanced diet, conservation of resources and so on, but not so with theoretical concepts. This kind of content according to the teachers could equip the learner to deal with social aspects of science adequately.

Since standard 9 to a large extent deals with an understanding of scientific concepts and laws, the teachers were of the opinion that the course is only partly suitable for those who would study science further.

According to ninety one percent of the teachers, the textbook gives most of the information (factual) and therefore does not seem to arouse the learners' curiosity to look up alternate sources of information.

Teachers opinion about the adequacy of text book content book was analysed and is shown below:

**TABLE 5**

**NATURE OF PRESENTATION OF CONTENT IN THE  
TEXTBOOK AND TEACHERS OPINION ABOUT THIS**

Item	Percent		
	Good	Adequate	Needs improvement
Language style (clarity of concepts)	-	23	77
Continuity of topics	-	47	53
Illustrations	18	48	34
End of chapter exercises	-	75	25
Examples	-	62	38
Scope for self study	-	-	100

Results show that, in the teachers' opinion, the language style needs improvement. Scope for self-study also needs improvement. In the teachers' opinion, the unfamiliar and difficult terms have to be separately explained which has not been done.

#### **5.3.3.4 Illustrations**

Data obtained from the teachers about the illustrations in the text book with respect to content elicited the following:

**TABLE 6**

Data obtained from the teachers about the illustrations in the textbook with respect to content

Item	Percent		
	Yes	No	Partly
Sufficient to supplement explanation	75	-	25
Helpful in clarifying concepts	67	33	-
Diagrams are self explanatory	50	25	5
Line diagrams are clear	100	-	-
Clarity of labels and captions	85	15	-
Photographs are clear	-	100	-

Illustrations were found by seventy five percent of teachers to be adequate and to be helpful in teaching and self-explanatory by fifty percent of them. All of the teachers are of the opinion that photographs are not clear.

#### **5.3.4 Section IV: Resources and Teaching-Learning Activities**

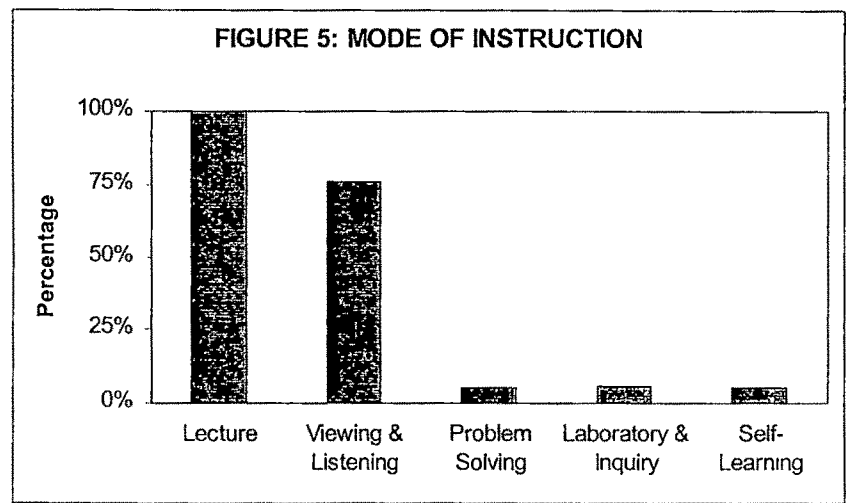
The following section gives teachers response regarding teaching learning activities and resources.

5.3.4.1Number of Science Periods Allotted per Week

There are four theory periods and one double period for practicals allotted every week.

5.3.4.2 Mode of Instruction

The teachers were asked to indicate the various modes of instruction they adopted to teach science. Their response is shown in figure 5.



The most often used mode of instruction as indicated by the response to the questionnaire was the LECTURE mode and viewing (Fig. 5), listening and answer mode.

All the teachers used lecture method for teaching and only five percent used problem solving and laboratory work for teaching science.

Teachers were asked through the questionnaire to indicate the strategies they used to develop problem solving and critical thinking in the learners.

**5.3.4.3 Strategies**

(a) Problem Solving through:

Solving numerical problems	60%
Questioning	20%
Science projects	7%

(b) Critical Thinking through:

Questioning	90%
Discussion	80%

Seventy percent of teachers responded that critical thinking in science developed automatically.

**5.3.4.4 Laboratory Work**

Opinion was sought from the teachers about the nature of laboratory work organized by them and the adequacy of resources.

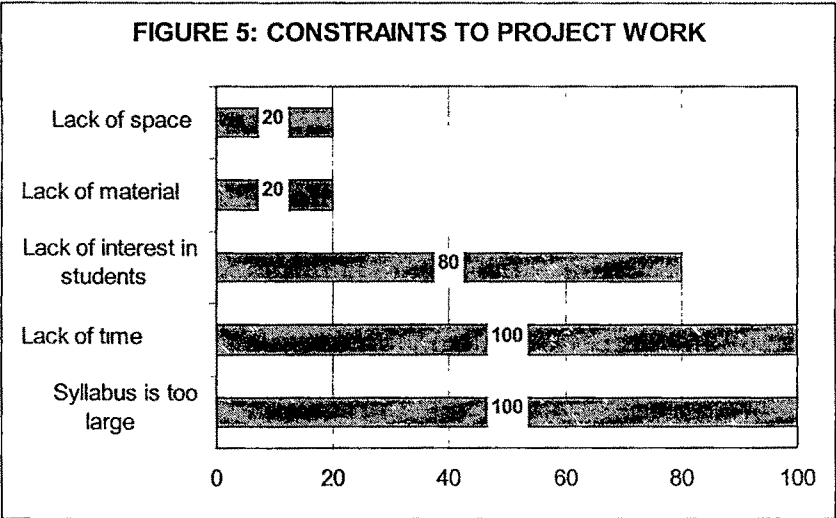
Provision for laboratory work	91%
Organisation of laboratory work	5%

Majority of the teachers (for the three grades together) responded that their schools had laboratory equipment but did not organise the laboratory work. However, in the follow up interview by the present investigator, it was clarified

by them that in respect of standard 9, where experiments have been mentioned in the text book, 20% of them organise laboratory work.

5.3.4.5 Scope for Project Work

Almost all the teachers agreed (as per their response to the questionnaire) that there was scope for project work. However they gave various reasons (Fig. ) for not organising the same.



Lack of time and syllabus being large were the two reasons mentioned by the teachers as constraints to the organization of project work.

5.3.4.6 Material Resources

Teachers were asked in the questionnaire about the adequacy of materials and the frequency of their use. Their response was as follows (all values in percentage):



TABLE 8

TEACHERS RESPONSE ON USE OF MATERIALS

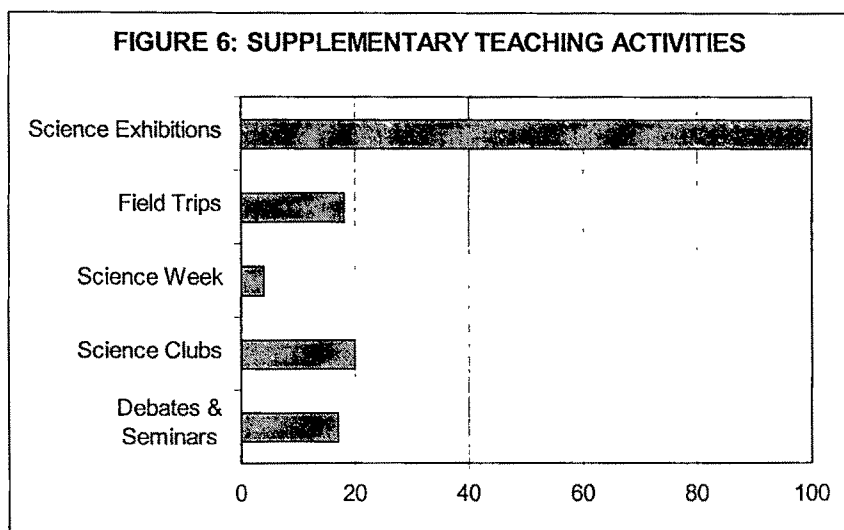
Adequacy			Frequency of use		
	Yes	No	Frequent	Occasionally	Rarely
Library books	74	36	-	-	-
By teachers	-	-	20	44	36
By students	-	-	8	22	70
Models, diagrams and charts	93	7	25	38	37

The data indicates that majority of teachers (74%) found the books adequate. However, use of these library books was frequent (20% of teachers), occasional (44% teachers) and rarely by the students.

Almost all the teachers said that they had sufficient number of charts and models, but only 25% use these frequently and 38% occasionally.

#### 5.3.4.7 Supplementary Teaching Activities

Data was sought from the teachers about the supplementary teaching activities organised by them relating to science. Their response is shown in Fig. 6.



All teachers indicated that the students regularly participated in science exhibitions organised for schools in Vadodara. Other supplementary activities organised were debates and seminars, science clubs and field trips (Fig.6).

#### 5.3.4.8 Assessment of Students in Science

The teachers assessed students through class tests, term and annual examinations.

#### 5.3.4.9 Methods Used for Assessment

Written examination is the only method used for assessment. According to all the teachers, it was revealed during the follow up interview that they consider written

test as the most appropriate way of assessing the proficiency of students in science. The teachers felt that the students should be able to write definition of terms, explain concepts, draw accurate diagrams as given in textbooks and solve numerical problems. As per their experience, all these could conveniently be assessed through written examinations only, which can be used for assessment.

#### **5.3.4.10 Home Assignments**

All the teachers indicated that the home assignment they gave mainly comprised of solving the end-of-chapter exercises as that would ensure the students reading the text books and getting prepared for assessment.

### **5.3.5 Section V: Overall Assessment of Science Curriculum**

This section gives the teachers overall assesement on the various attributes

### 5.3.5.1 Process Skills Developed Through Teaching of Science

TABLE 9

#### DEVELOPMENT OF PROCESS SKILLS

Item	Percent teachers
Classification	100
Communication	No response
Observation	100
Hypothesising	No
Interpreting data	10
Questioning	10

#### Teachers' opinion

Data was gathered about the process skills developed through the present science curriculum. Results are as follows:

Follow up interviews with the teachers indicated that the process skills which teachers consider to be developed to a large extent are Classification and Observation. According to them, the students come across many instances of classification (of matter, elements, resources, living organisms etc.) as well as that

of observation, in the textbooks and teaching of science. A few teachers (10%) indicated that students learn to interpret data presented in graphs, while learning about time, distance, velocity and other related graphical representations in standard 9.

**5.3.5.2Capabilities Expected to be Attained by Learners at the End of Secondary Level of Science Education - Teachers Opinion**

Regarding the attainment by the learners at the school leaving stage, the teachers' response to the questionnaire was analysed. Results are given in table below.

**TABLE 10**  
**CAPABILITIES EXPECTED TO BE ATTAINED**  
**BY THE LEARNERS: TEACHERS' OPINION**

Item	Percentage		
	Yes	No	To some extent
Acquire understanding of scientific concepts	100	-	-
Develop problem solving skills	75	25	-
Develop manipulative (apparatus handling) skills	5	87	-
Help pursue higher education in sciences	30	70	-
Sensitivity towards environmental concerns	67	33	-
Understand interdependence of science & technology and society (S T S issues)	-	59	41

The results show that majority of teachers are of the opinion that at the end of the secondary school stage, the learners acquire understanding of scientific concepts (100%), develop problem solving skills (in their perspective, this refers to solving numerical problems), sensitivity to environmental concerns (67%). However with respect to manipulative skills (87% of teachers), and pursuing higher education, they feel that the learners may not acquire these capabilities to the extent desired. Regarding understanding of interdependence of STS issues by the learners, the teachers' response was not affirmative.

#### **5.4 ANALYSIS OF SCIENCE TEXTBOOKS**

The textbook is the most widely used teaching aid in the class room and most often becomes synonymous with the 'curriculum' and in fact serves as a '*de facto*' curriculum (Kumar 1992). The textbook thus commands a central role in the translation of a curriculum and the instructional activities get centred around the textbook. The textbook comes to serve as a comprehensive source of information (Goodlad, 1984), and at times, it becomes the representative of both, the intended and the implemented curriculum.

The textbooks of secondary school level (standards 8 to 10) were analysed with reference to the guidelines laid down by the NCERT for textbook preparation and objectives of teaching science including the perspective of scientific literacy.

### 5.4.1 Organization of the Content in the Text Books

The guidelines lay down by NCERT, and the prevailing features of the textbook, along with teachers' opinion as revealed in the present investigation are presented below.

1. **Learning objectives should be stated at the beginning of each unit (NCERT, 1990).**

The examination of textbook revealed that :

- i. The chapters have **not** been categorised into units.
  - ii. Learning objectives have not been stated.
2. **The topic movement should be from concrete to abstract or formal concepts.**

It was found that the topics in the textbook of each grade did not follow any such principle in their sequence; however, the chapterization indicates that the hierarchy of concepts has been maintained.

The content has been organised as different chapters in all the three grades (refer Appendix 2) for list of contents of books) e.g. Chemical bonding, Describing motion, Force and acceleration, Living Organisms and Habitat, Science, Technology and Man, Biosphere, Metallic elements, Organic compounds and so on.

The important feature about content was that formal concepts in science predominate the Standard 9th textbook (refer list of contents in appendix 2): Properties of matter, chemical bonding, chemical reaction, energy changes, motion, force and acceleration, gravitation, work energy, life processes, and so on. A few concepts appear in Standard 8 such as pressure, light and magnetism. In Standard 10, formal concepts are not dealt with.

#### **5.4.2 Sequencing of Content Across Grade Levels**

It was also observed that the continuity (sequencing) across the grade levels was not consistent. The topics appearing in grade 8 are mostly extended in grade 10 and not so much in grade 9. Only three chapters could be identified which appear in grade 8 and do get extended to grade 9, i.e. light, electric current, atom and its properties.

#### **5.4.3 Instructional Approach**

The instructional approach stresses on science as inquiry and takes into consideration the process skills (NCERT, 1990).

The content in prescribed textbook represents science as a body of knowledge and the "inquiry" approach is not evident. The activities have been included as experiments, but these experiments have been written out and the explanation given there itself in the chapter. Hence the student and teacher may not have



become inclined to try out the suggested activities to find out what happens.

It was examined whether the content within each chapter was organised in such a way that concrete examples precede formal/abstract ones. This revealed that within the chapter (topic) also there was some attempt to organise the content in such a manner.

For example, in standard 9, the chapter on properties of matter precedes classification of elements and chemical bonding. Similarly, the chapter on 'describing motion' and so on precedes the content on force and acceleration.

The chapters have been so organised that the concept is further extended to other concepts and the fundamental concepts precede the more sophisticated concepts in accordance with the suggestions (NCERT, 1990).

In the textbook of Standard 10 however, each of the concepts do not seem connected sequentially as the topics are varied. The topics included are Fossil fuel, Combustion, Balanced Diet, Deficiency diseases, Natural wealth and so on which are not directly related to each other. The topics generally are related to certain issues like conservation of fuels, necessity of health and hygiene, ecology, etc.

The content in the textbooks has been organised in terms of chapters on various topics. The organisation is flexible enough to permit variation in the sequence.

Also the chapters can be grouped under the three disciplines of science viz. physics, chemistry, and biology. The nature of topics are independent entities, and principles of sequence and could not be applied. Hence the content cannot be considered to reflect an integrated approach to science.

#### **5.4.4 Interdisciplinary Approach in the Instructional Material**

At the secondary level the aim of teaching science is towards problem solving and decision making through the learning of key concepts which cut across all disciplines of science (NCERT, 1986). Learners' experience of the laws of nature is not as that of a physicist, chemist or biologist hence the unity of science needs to be reflected in the course content. The content is expected to reflect the integrated approach in science, through its organisation around some key principles and concepts, which cut across all disciplines of science (e.g. Cause and effect, change, energy and matter, environment, force so on).

The content analysis of the textbooks under investigation indicated that interdisciplinary approach in science is not all through reflected in the content. The topics in science have been organised apparently as topics related to physics, chemistry and biology. The above is the feature of the std. 9 textbooks where the first five chapters relate to chemistry (refer Appendix 2), the next nine chapters relate to principles and concepts in physics and the rest to life sciences. The scope available in integrating the concepts across the disciplines does not seem to have

been explored in the textbooks. For example, the concept of 'heat' can be related to the chemical reactions and chemical changes as well as physical change in the state of matter, and also the biochemical reactions in the human body.

In the standard 10 textbook, the topics pertain to health, balanced diet, energy crisis natural wealth, where, chapters have been treated as individual units, and wherever integration is possible it is not reflected e.g. the content on health, balanced diet and deficiency diseases can be made more meaningful if integrated appropriately rather than as separate and individual units.

#### **5.4.5 Content and Coherence with the Objectives of Science**

The objectives of teaching science at the secondary level have been stated in the earlier sections. The textbook represents the knowledge to be conveyed through the instructional process. In accordance with the curriculum theory, it may be recalled that the content selected needs to be coherent with the objectives of the curriculum (Wiles and Bondi, 1989; Ornstein and Hunkins 1989). The objective of teaching science at the secondary level is to equip the learners with certain essential competencies in terms of knowledge, skills and attitudes, which become useful to all students, and meets the requirements of scientific literacy.

It is expected that the learner at the secondary stage will not only grasp the basic structure and principles of science but also be able to relate science with agriculture, industry, energy, environment, health and contemporary areas of

national development. It is also expected that learner will become competent in using the skills of science by developing instrumental, communicating and problem solving skills, and become aware of the interdependence of science, technology and society.



The content analysis of the textbooks at the secondary level indicated that content could be categorised as:

Content related to scientific concepts, laws and principles.

Content related to conservation and preservation of environment, health, industry, agriculture and so on.

#### **5.4.6 Scientific Laws, Principles and Facts**

An adequate amount of content is devoted to acquire an understanding about laws of motion, work and energy, chemical bonding, chemical reactions and life processes. The std. 9 content predominately has content related to the formal concepts in science. The learners are provided with a detailed study of various properties of matter, classification of elements, different kinds of chemical bonding, energy changes in chemical reactions, laws of motion, properties of light and related concepts like reflection, refraction, dispersion and mixing of colours, the various life processes in plants and animals (respiration, nutrition and reproduction, etc.). In standard 10 the content stresses more on issues related to environment such as fossil fuels, energy crisis, bio-resources and biosphere; health

related information regarding balanced diet, deficiency diseases, and food preservation. The content also includes information regarding development of agriculture, maintenance of livestock, organic compounds and industrial products such as artificial fibres, plastics, soaps and detergents, and extraction of metals.

This kind of course content reflects the objective of understanding of scientific laws and concepts in the learner. The course content also provides a number of suggested activities and experiments, which would enable the learner not only to understand the concepts better, but also help him/her, conduct experimental work related to the scientific concepts.

#### **5.4.7 Activities, Experiments, Problem Solving Skills**

The learner is expected to develop problem-solving skills and acquire skills in formulating and designing simple experiments. According to the guidelines the course content needs to include material on development of problem-solving skills. It also directs that simple activities be given to enhance the understanding of concepts and their application.

The content analysis on this objective revealed that in the textbook of std. 9, experiments and activities were given in the topics related to chemical reactions, gravitation, heat and temperature, electric current. However, a common feature regarding these activities and experiments noticed was that the results of the same were also given along with them. In other words, these were conclusive in nature.

The list of experiments given at the end of the textbook are those, which relate to verifying the laws or principles learnt in the course. Only one activity could be identified in the textbook, which was open-ended (std. 9) and posed a problem to students (p. 186). Content is relevant to both – those who are likely to study science further and those who may not.

The secondary level is the climax for general education and also a large number of students may not opt for science in higher education. This implies that the science course should have content, which would equip the learner with an understanding of science concepts, principles, which cut across through all disciplines. An attribute of a scientifically literate individual is an essential grasp of some fundamental concepts, laws and principles which would enable the learner to interact with the environment in a fruitful manner and apply the same in daily life (Bybee, 1995).

The analysis of content further revealed that it adequately meets the needs of both kinds of learners in terms of knowledge about concepts, principles and laws. The standard 9 content predominately enables the learner to acquire the concepts, principles and laws in science. The standard 10 content deals with issues related to human being's environment such as health, conservation of natural resources, preservation of ecosystem and so on.

However, the manner of application of the knowledge about science laws, concepts, etc. in studying and solving problems related to one's environment does not seem to have been appropriately highlighted.

#### **5.4.8 Illustrations**

The NCERT guidelines suggest that:

- i. Photographs are clear.
- ii. Line drawings are well executed.
- iii. Illustrations are coherent with the content.
- iv. Captions are appropriate.
- v. Support in teaching.
- vi. Do not constitute more than 33% of the text.

A proper illustration helps in enhancing the understanding of the content. Illustrations need to be selected on the basis of relevance, quality and quantity (Chiapetta and Collette 1984). The purpose of the illustrations is to aid in explaining concepts or examples or conveying some information (graphs and tables).

#### 5.4.9 Line Drawings and Diagrams and Figures

This category constitutes the majority of the illustrations given in the text for all the three grade levels. Diagrams have been used in the textbooks to convey the content on various aspects of life processes in standard 9 (p. 180, 182, to, 185, 192, 193) such as circulation of blood, respiratory system, cell division, reproductive system, structure of heart, nerve cell and brain. Diagrams include representation of the structure of animal and plant cells, parts of a flower and various microorganisms (p. 164, 165, 175, 188, 189, 192).

Similarly diagrams have also been used to explain electric circuits, magnetism, wave motion, and chemical processes like electrolysis, froth floatation, preparation of gases and distillation.

The kind of illustrations which appear in the textbooks were:

Class	VIII	IX	X
Figures and diagrams	87	98	35
Graphs	0	17	4
Tables	13	26	20
Photographs	4	0	7



#### **5.4.10 Figures and Diagrams**

Across the three grades there is an abundance of this form of illustration viz. figures and graphs. These were used to represent the shapes of molecules (for e.g. standard 9 fig 3.2,3.3; standard 10 fig. 13.1, 13.2, 13.3 & 13.4) the movement of waves for e.g. standard 9 fig 9.3 & 9.4). Some of the chemical processes e.g. standard 9 (fig 5.1) standard 10 fig. 14.2 preparation of ethane, methane; froth floatation) the process of electrolysis, the cell structure of plant and animal cells, the cell (fig. 17.2) division process (standard 9, fig. 17.3, 17.4 & 17.5), electric circuits (standard 9, fig. 13.8, 13.9). These were found to be relevant and enhanced the understanding of the content.

#### **5.4.11 Graphs**

Graphs depicted in the textbooks have been clearly labelled and help in communicating the content to the learner. In std. 8 no graphs have been used. Graphs appear in standard 9 and standard 10. The graphs in standard 9 have been used mainly to describe the motion of the body (p. 45, 51, 52, 53, 54, 55, 56, 58, 59, 61) through distance-time graphs & speed-time graphs. A majority of the graphs appear related to the topic related to motion of a body in standard 9 (Chapter 6, Chapter 7) and represent time-distance graphs and speed vs. time graphs. The other graphs which appear are, temperature-time graph for change of state of matter (pg. 118) and current-voltage graph (pg. 133) representing the Ohm's law.

In standard 10, bar graphs have been used to convey information regarding energy requirements based on age and workload of human beings (p. 31). The only other graph (p. 32) represents the proportion of components in food items. All the graphs had clarity and conveyed the information effectively. The graphs had appropriate titles and the variables (X and Y-axis) are clearly labelled. The manner of representation of different items has also been clearly indexed. The graphs were all found to be coherent and relevant to the content.

#### **5.4.12 Tables**

A number of tables have been included in the textbooks. E.g. Calorific value of fuels, std.10 p.13., sources and functions of minerals, p36., Alcohols and esters p.121,122., Std.9:Historical development of science and technology, p. 209, 211., Animal hormones and functions p.196. These tables supplement the information given in the text.

#### **5.4.13 Photographs**

A total of 8 photographs could be found in textbooks across the three grades. The photographs used in the textbooks were very few and lacked clarity. For e.g. in Std. 10 p. 65 & 67 where photographs depict the hazardous effects of radiation. The photographs on pg. 41 & 42 (deficiency diseases) however contain clarity. The photographs used are relevant to the content for e.g. the photographs depicting

the deficiency disease (std. 10, pg. 41-43) or the various kinds of animal hybrids radiation (pg. 65-66). However, it was observed that these photographs lacked clarity, especially the photographs relating to hazards of radiation and deficiency diseases. The photograph on p. 61 was captioned as animal husbandry whereas this phrase does not appear in the textbook.

#### **5.4.14 Overall Analysis (Illustrations)**

In the overall analysis, it was found that the line drawings have been well executed and the graphs have been appropriately labelled and clear captions are given. However, in a few instances the illustrations did not appear coherent with the content or relevant or properly labelled. For e.g. the diagram on earthquake waves lacked clarity (fig. 9.5, pg. 99, Std. 9).

#### **5.4.15 STS Issues in the Content**

The textbooks prepared by Gujarat State Textbook Board were examined in order to identify the STS related topics at the secondary school level (grade 8, 9, and 10). The content matter in the textbook can be described as dealing with STS interaction (Chiapetta, Sethna & Filman, 1993) if it portrays the effects of science on society and how technology helps or hinders human kind. For the content matter to be identified as pertaining to STS it needs to include:

- i. Description about the usefulness of science and technology to society;
- ii. Emphasise both the positive and negative aspects of scientific and

- technological progress in relation to societal context; and,
- iii. Discuss the social issue related to science and technology.

The examination of science textbooks of grade 8,9, and 10 with respect to representation of STS issues indicated that, the STS issues are presented in a factual manner rather than as issues which would enable the learner to interact with the text material by utilising one's own experiences as envisaged in the curricular intentions. Some pertinent issues related to STS almost find no mention in the textbooks such as information with regard to population education in particular, reference to family welfare and impact of over population. In the topics related to STS issues, represented in the text, a majority of them presented seem to need more elaboration with respect to societal context or to learner's personal experiences. The content comes across as individual entities e.g. in the text related to balanced diet, information on deficiency diseases is too factual. The manner of presentation of topics related to conservation of natural resources, energy crisis and ecological imbalances is such that they do not seem to arouse the learner's involved concern for the same citing examples from the region (in the present case Gujarat State) in which the learners are located.

Another feature of the content examined shows that across the grade level there is no continuity of the topics and even when the topic is revisited there is no reference to what the learners may have come across at an earlier grade. In this context the content related to conservation of natural resources offers an excellent

example; this topic has been included at both the grade levels eight and ten without significant difference in content matter. For the three grades together, only one chapter deals with the impact of development of science and technology on society historically. Another serious shortcoming of the prescribed textbooks has been the inadequate representation about the consequent use and misuse of science and technology. It therefore emerges that although STS issues have found their way into the textbooks, their representation needs to be improved by including more STS related information.

## **5.5 RESULTS OF QUESTION PAPER ANALYSIS**

Questions set for the annual examination were analysed. The sample comprised of a total of 40 question papers from 16 schools of their term and annual examinations.

The analysis of question papers was done on following aspects:

Typology of items -- whether they are multiple choice questions, long answers or short answers.

Content of questions -- the aspect of science knowledge tested.

All the question papers had the following kind of items:

- (1) Short answers: students were expected to answer these questions in one word or one sentence, or provide definitions.

The content of these questions comprised of asking students

- (i) to explain abbreviations/ acronyms e.g. BARC, CFTI etc.
  - (ii) to state the name of particular category of substances/organisms e.g. name bacteria which curdles milk; chemical name of teflon
  - (iii) to give composition of a substance e.g. composition of LPG, soda lime etc.
  - (iv) definitions e.g. of velocity, momentum etc.
- (2) Items asking students to draw diagrams and describe the process e.g. diagram, and description of the process of obtaining pure copper; construction and working of voltaic cell (std. 8); digestive system of a human being (std. 9); or description of well managed farms (std. 8).
- (3) Writing short notes

In these items the students were expected to write short notes about various topics e.g. short note on green house effect; polyethene; insecticides; Darwin's Theory of Evolution (Std. 8). Newton's law, gravitation, solar energy, milk is a complete food (standard 9).

- (4) Explaining concepts or phenomena through reasoning; a few questions were asked which require the learners to provide the scientific explanation behind the phenomena or provide reasons about certain observations. e.g., Why are astronauts required to wear a special kind of dress? Why is bio-gas plant a blessing to the farmers? How is a star born?

- (5) Differentiate between: In these items the students were asked to differentiate between two processes, substances, or organisms. E.g., conventional and non-conventional sources of energy (std.8); thermo-plastics and thermo-setting plastics; artificial and vulcanized rubber and so on (std. 10).
- (6) Description of experiments: One item was found to specifically provide the description of an experiment which proves a law or explains a concept or a phenomena. E.g., Describe an experiment to determine the parallelogram law of forces (std. 9). Describe an experiment to demonstrate that it is necessary to sow seeds at an appropriate depth.

The analysis presented above indicates that although a variety of items were present in the question papers, the content of the questions serves the purpose of only testing if the students could retrieve or recall the appropriate information. The weightage of marks assigned to reasoning questions which involves thinking skills of higher order was found to be only 10% of the total in all the question papers examined.

It was also found that questions were based completely on textbook content and end-of-chapter exercises. The teachers in the interview indicated that they expected students to write the explanations given in the textbooks.

## **5.6 SCIENCE CURRICULUM AND ITS TRANSACTION: DISCUSSION**

The present study sought to evaluate the secondary school science curriculum through a study of its structural and operational features. It has tried to examine the perspective of scientific literacy through the study of curricular intentions and transactions. The data obtained from different sources such as: documents, curriculum proposals, classroom observations, interviews with teachers and response to the questionnaire specifically designed for the purpose have been put together to construct the science curriculum as it manifests in the actual settings and to examine its congruency with the intentions.

It was earlier stated that the major objective of the curriculum at secondary level under investigation is the development of scientific literacy among the learners. It is known that successful realisation of curricular intention in its operational phase is logically contingent on the structural components of the curriculum (Stakes 1967, 1973) as well as the operational aspects.

The results presented above on various aspects of realisation of the curricular objectives bring out that science curriculum as it is being transacted in the classroom environment is at variance with the objectives envisaged.



### 5.6.1 Objectives of Science Education

The objectives formulated and enunciated in the curricular documents cover the different dimensions of scientific literacy as also described by Yager (1993) and Bybee (1995). Analysis of textbook content prescribed at secondary level indicates that if textbooks for all three grades are viewed holistically, only then, the content can be considered to be relevant to the tenets of scientific literacy as well as the objectives of teaching science with a few exceptions. The recommended instructional practices (NCERT, 1990) as well as assessment procedures are in consonance with the curricular intentions.

However, a perusal of the results given above on the ‘operational’ aspect of curriculum transaction (obtained through classroom observations, questionnaire and follow up interviews with teachers) indicates a *lacuna between the intended and the transacted* curriculum. This is reflected in the results on teachers' perception about curricular objectives, their choice of instructional strategies and practices adopted in the classroom including the assessment procedures. These are further elaborated below in relations to the results.

### 5.6.2 Teachers Opinion About the Curriculum Objectives in Science

Teachers' opinion on their understanding of "scientific literacy" as evident from their response to the questionnaires is seen to be limited to acquisition of ‘scientific knowledge’ by the learners (almost all teachers). Very few of them

consider it to encompass application of scientific knowledge (15%) and understanding of societal issues (5%). Results show that some teachers had not come across the term 'scientific literacy' and seem to be unaware of the present curricular trends. It is relevant to note here that Yashpal Committee had recommended the development of seven dimensions of science curriculum with main focus on scientific literacy.

The teachers conveyed that the objectives of science curriculum, which they consider significant, are:

- (a) that students should acquire scientific knowledge (laws, theories, principles etc.), and,
- (b) giving the learner an adequate exposure to practical work.

Thus the shared view among the teachers which emerges about science curriculum intentions with respect to the learners are the emphasis on '*learning*' *scientific knowledge* and secondly exposure of the learners to laboratory through simple experiments. About the rest of the curricular objectives, most of the teachers opined during the interviews that students would be able to acquire scientific temper, attitude etc., if they 'learn science properly'.

These results endorse the view expressed by Oakes (1992), Cuban (1995), and Yerrick (1998):

- (a) that the responsibility of any curriculum transaction depends on the

teachers

- (b) that the teachers' construction of curriculum has a direct bearing on classroom practices and any consequent lacuna between the intentions of the curriculum developers and those shared by teachers.

### 5.6.3 Functionality and Feasibility of Objectives

As mentioned in the results, the curricular documents state only the curricular intentions but not the process of achieving the same. This observation is also reflected in the teachers response (70%) with respect to the objective of developing communicational skills, scientific temper, attitude, process skills among the learners which the teachers feel needs to be *supported by directions* about how to achieve these in the learners through the text book content.

The results show that in the opinion of the rest 30% of teachers, *the teaching of 'science' (by which they mean all the content in textbooks) would easily take care of achieving all the objectives* stated in the curricular document and did not see any need for further clarification of the objectives. Their reasoning seems to be that since the textbook would have taken care of all the curricular objectives, transacting the textbook material in full should "automatically and adequately" cover this aspect. This situation is inevitable in a textbook centred transaction where the textbook is the *de facto* curriculum (Kumar, 1992).

About feasibility of objectives the opinion is equally divided among those who say 'feasible', 'partly feasible' and 'not feasible'. Results show that according to 70% of the teachers, the objectives which get taken care of in the class room environment, are the ones related to acquisition of scientific knowledge and developing some manipulative skills.

The teachers (29 %) who find none of the objectives to be feasible are of the opinion that the *student usually ended up memorizing science content* and not actually understanding the concepts. Hence they do not think any of the objectives as being really feasible in their strictest sense.

One point evident from the analysis of the results is that in the teachers opinion, achievement of objectives become both functional and feasible if only adequately supported by content in the text which, in their view, is not the case at present.

Considering that the objectives signify the intended values, images and practices which are associated with the curriculum under implementation, the teachers' opinion is noteworthy. This leads to the conclusion that :

- (i) the teachers share only a limited understanding of the curricular objectives regarding science literacy
- (ii) the curricular objectives do not include clear directions with regard to the educational activities to be pursued and guide in the selection of appropriate content, instructional strategies learning experiences etc., which is felt

helpful (Shourie and Shrivastava, 1988) at the operational level.

The *exploration* regarding the various aspects of the objectives of science curriculum undertaken by the present investigator indicates that in view of these results and the teachers view, a wider and shared meaning of the "Official" curricular intentions need to be made more explicit by reflecting the ways and means of their realization in the textbook content. The result about teachers' views on objectives assumes significance in the light of classroom practices adopted by the teachers, which forms an important part of the present investigation and is discussed below.

#### **5.6.4 Instructional Practices**

Appropriate instructional strategies are expected to be adopted in the classroom (NCERT, 1990) which would lead to spread of science literacy among the learners.

Results have shown that the teachers find the lecture method as the most appropriate for transaction of curriculum in the classroom. It is mostly the "taught" curriculum that is what manifests during the transaction in the classroom. In view of the nature of content (formal scientific concepts for std. 9) which need elaborate explanation, vastness of class size, time constraint and the content, the teachers feel this to be the most practicable strategy. While nature of subject

matter and content have been stated to be important for selection of an appropriate instructional strategy (Merzin, 1987; Rigden, 1991; Smith et al. 1991), adoption of lecture method is considered convenient where there are constraints of time, and class strength is high (Chiapetta and Collette, 1984, Flemming, 1989).

It is interesting to note that the content prescribed for std.10, (environment, conservation of resources, historical development) which have been reckoned to be an important part of science education (Harms and Yager, 1984; Bybee, 1997) for developing scientific literacy, and considered critical to teach about nature of scientific knowledge to enable learners in decision making in social (STS) issues AAAS (1989), Flemming (1989), the teachers find it to comprise of *general topics* but not of *real science*.

They view these topics to be *self-explanatory* and could be taught easily or learnt simply by self reading and not needing elaborate explanation or adoption of activity-based teaching strategies. Hence their preference for lecture method. To this extent the traditional positivistic approach to science education which was reflected in the classrooms observed limits the understanding of the nature of scientific knowledge as mentioned by Bingle and Gaskell (1994).

It may not therefore be surprising to find that teachers, the products of traditional science curricula limit themselves to the teaching of formal concepts (Traweek, 1988) at times, leaving the STS issues to be pursued by the learners on their own.

In this context, it should be recalled that the traditional positivistic representation of science knowledge and teaching are considered inadequate as means of understanding the social aspects (Fleck, 1979; Latour, 1989; Rorty, 1989; Tobin et al 1990). Instead, the constructivist approach to science teaching is thought to be more relevant to meet the requirements for spreading scientific literacy and transaction of STS issues (Lorsbach and Tobin, 1992).

Viewed thus, the use of lecture method for these topics as opined and practised by the teachers in schools at Vadodara has to be considered as an inadequate instructional strategy.

The teachers who had been using the lecture cum discussion (10%) or activity based instructional approach (6%) remarked that they could use these approaches only occasionally for some selected topics, since these methods, though quite helpful and most appropriate for developing process skills, *led to running short of time*. Keeping in view the constraints expressed by these teachers, in the investigator's view, lecture method combined judiciously with discussion or activity, for 'selected topics' might facilitate adoption of a more appropriate and practicable alternate strategy in the classroom environment.

### 5.6.5 Non-Conventional Methods of Teaching

Results on classroom observations show that about 14% of the teachers follow read aloud/read aloud with vernacular translation; read aloud accompanied by silent reading and question-answers, which are considered non-conventional. The teachers say that their main concern is to make certain that students *learn science* and succeed at the examination. Their reasoning was that although they had been made aware of alternate methodologies to teach science in their teacher education courses, while planning their teaching strategy, they had to keep in view the actual classroom setting, implying thereby, covering the content in the prescribed text books in time, ensure students learning and expected success. In the actual classroom transaction, teacher's choice about what to teach and how to present the particular subject matter by their experiences and their knowledge, (Hawthorne, 1992; Cuban, 1995) has been stated as an important feature.

In the case of science teaching it is considered important (NCERT, 1990, NPE-86) to stress on different aspects of science--science as a body of knowledge, as a method, and as a way of thinking. In this context, lecture method as an instructional strategy, is said to have a limitation in developing the connection between the concepts (logical plane) and experiential evidential support (evidential plane) as expressed by Stinner (1992). In the opinion of Lemke (1990), and Driver et al. (1994) this connection is important as this reflects the



dynamic nature of science.

It is pertinent to recall here that the teaching methodology come across in majority of the classrooms most of the time has been the *lecture method* which conveys *science as a body of information to be transmitted*. There is a general agreement that science from middle school level is taught chiefly by way of the established *scientific fact* and as *a finished product* (Hewitt, 1990; von Bayer 1990; and Rigden, 1991).

This approach also severely restricts the development of understanding about the 'nature of science' contrary to stated curricular intentions.

#### **5.6.6 Explanation of Concepts**

Concepts in science are supposed to be explained by discussing the different aspects, their relation to other concepts including those learnt previously and further exploring the possible experimental and experiential evidence related to the concept, as well as examples one may come across in daily life (Renner et al., 1990; Martin, 1990; Hazen, 1991). In contrast to this, results show that in the majority of classrooms observed in this investigation, **passing of information or translation onto vernacular language is what constitutes (in the opinion of teachers) an 'explanation of concepts' and not through generation of questions, activity or student participation.**

The manner of explanation of concepts in actual classroom transaction may thus be considered to be a result of textbook centred science teaching whereby students may see little connection between their observation of the world and what they learn in science (Aufsnaiter, 1989; Stinner, 1992). In the opinion of von Bayer (1990), such a situation in turn leads to the students memorising the scientific ‘facts’ rather than promoting the understanding of concepts based on detailed explanation in the manner envisaged.

#### **5.6.7 Practicals in the Classroom**

Practical work (learning by doing) has been recommended (NCERT, 1990) as an integral part of science curriculum to enable the learner to acquire process skills which would help in interacting with environment and in daily life. The practical work is not only expected to develop instrumental, communicational and problem-solving skills (NCERT 1990) but also assist in acquisition of scientific concepts (Stinner, 1992; Hewitt, 1990). However, the results show that the instructional strategies practised in the school do not help in realising this curricular intention in practice.

#### **5.6.8 Questions Asked in Classrooms**

Questions have been an integral part of teaching and learning process. The use of

‘good’/appropriate questions in science teaching has been found to be useful in bringing about conceptual changes, elicit student explanations, elaboration of previously learnt answers, and predictions that may contradict student's intuitive ideas about natural phenomena (Carlsen, 1993; Smith et al., 1993; Blakeslee and Anderson, 1993; and Roth, 1996).

Regarding the *nature and use of questions* put by the teachers in the classroom transaction, results described in the episodes in earlier pages show that, questions are in general, used to introduce or close a lesson or to get the learner's attention to the concept being taught, to help in the progress of the lesson and finally to evaluate the students at the examination time.

In the few instances where the students were given some opportunity to discuss, the teachers asserted their authority by subsequent questioning and other means. At times, the teachers were observed to have a tendency to interrupt the students' account, allowing very little *wait-time*. This perhaps describes the situation reported by (Roth 1993) that teachers are able to ensure their assertion and the students' submission even in *absence of overt* teachers' control.

It is also noticed from the results that use of questions in terms of number or range is quite limited and also for a limited purpose. In science classrooms the typology of questions is expected to address the knowledge related to natural world, knowledge related to processes of science, (classification, formulation of

hypothesis, testing of information), knowledge related to testing of information and eliciting students' explanations, elaboration of previous answers, ideas, knowledge (Lemke, 1990; Roth, 1996).

In view of the fact that teachers pursue a textbook centred teaching through lecture method, in a period of 35 minutes duration, they find it *difficult to ask more than three or four questions*. Together it can be seen that role of questions, which is so important to teaching science gets reduced to a very limited exercise and does not help in promoting scientific inquiry, critical thinking (Graesser and Pearson, 1994; Roth and Bowen, 1995) or understanding of concepts.

Thus, the nature of questions put by the teachers serve the purpose of allowing the teachers to maintain a tight control of classroom discourses in terms of knowledge (information) to be taught, sequence and evaluation as opined by Lemke (1990), and Poole (1994), restricting student participation in the classroom.

It may therefore be concluded that entire *pattern of questioning/ discourse* in class rooms in the schools investigated can be described linguistically as being IRE (Teacher Initiated Question and Student response and teacher evaluation), mentioned by Cazden (1988), Lemke (1990); Carlsen (1991); and Poole (1994).

#### **5.6.9 Laboratory Work**

Laboratory work and activity based teaching and learning in science are essential

to achieve the objective of putting many theories on sound footing as well as promoting inquiry and problem solving skills (Hofstein and Lunetta, 1982; Tobin, 1990; Rutherford and Ahlgren, 1990). This also allows students to handle various kinds of apparatus (manipulative skills), to learn how readings are to be taken, how work can be organised systematically, to record data and to draw inference i.e., application of the whole scientific process which they read in standard 6.

Results show that teachers consider teaching of science concepts and laboratory work as 'independent' entities. A full description of the experiments with results is given in the content, and the teachers feel that these as well could be read without actually performing the tasks in the laboratory.

This is attributable to the *textbook centred* nature of science teaching whereby the link between the theory and practical work is not made evident, by either the absence of practical work or "poorly" organised practical work in the classroom. Lack of time is one of the reasons attributed by the teachers.

#### **5.6.10 Project Work**

Science teaching is not to be restricted to the teaching of concepts alone. It envisages acquiring problem solving and Process skills based on the curricular intention of scientific literacy (NCERT, 1990). Results show that all teachers see the scope for project work, especially for simple topics related to STS issues in

std.10. However, they put forth lack of time, and lack of students' interest as constraints for the organisation of project work. Also as discussed earlier, these topics are viewed by them as quite simple and could be taught easily through lecture method. Hence projects which bridge the gap between learners' knowledge and solution to problem through exploration and investigation (Dhillon, 1998) are not an active part of the transacted curriculum.

#### **5.6.11 Use of Teaching and Audiovisual Aids and Other Resources**

Results from this investigation show that in spite of availability of audio-visual teaching aids and other resources like models, charts, library books, these are rarely put to use by the teachers. Even where they are used, the learners are asked to copy the diagrams from the textbook rather than from the specimens or charts shown to them. Reason given is that since most of the diagrams are already contained in the textbook, whenever required the students could be asked to refer to the textbooks. This reiterates the textbook centred approach to science teaching and how important the textbook is looked upon in classroom transaction. Any improvement in transaction may have to be effected through the textbook.

#### **5.6.12 Assignments and Assessment Procedures**

Classroom observations show that assignments given to the learners are limited to end-of-chapter exercises, the answers to which are either dictated or marked in the

text as home assignment. Assessment is done through written examinations limited to testing the learners ability to 'reproduce the facts' as given in the prescribed textbooks.

Thus both the assignments given and the assessment procedures do not encompass all the curricular intentions of science education. Assessment procedures adopted are expected not only to test acquisition of science concepts, but also to assess use of scientific method, instrumental skills, and understanding of STS issues (NCERT 1990) by the learners. Thus both, the assignments given or the assessment procedures adopted do not encompass all the curricular intentions of science education.

#### **5.6.13 Development of Process Skills**

An important aspect of science teaching is the development of process skills to help in problem solving and critical thinking in the learners as envisaged in the curriculum proposal (NCERT, 1990). Results on classroom observations do not show any evidence of teachers trying to focus on development of process skills. It is also of interest to note that most of the teachers feel that solving numerical problems serves the purpose of developing problem-solving skills.

There is general agreement that science from middle school (in school) is taught

chiefly by way of the established "scientific fact" and as a finished product (Hewitt, 1990; von Bayer, 1990; Rigden, 1991). Science teaching being textbook centred, suggests that teaching takes place on the 'logical plane' (mathematical algorithm-factual). There are very few instances where teaching occurs in the evidential (experiential – experimental - intuitive) plane (Renner et al., 1990). It is mostly the "taught" curriculum that is what manifests during the transaction in the classroom.

The above discussion shows that irrespective of changes in curriculum, the teachers continue to use the practices developed over a time period. This reiterates the observation that teachers believe teaching as it happens in the classroom is relatively independent of knowledge gained about pedagogy through formal courses (Roth 1998).

#### **5.6.14 Textbook Content and Objectives of Science Curriculum**

The textbooks for science have been prepared by Gujarat Board of Education based on the recommendations of NPE-86 for use in secondary schools for science education. Results on examination of the prescribed secondary level science text books with reference to curriculum guidelines (NCERT 1990) and also the principles of selection and organisation as given by Smith et al (1956), Barrow (1984) and Armstrong (1989), show that only if a holistic view of the content in the textbooks for the three grades 8 to 10 is taken together, one could say that the



intended objectives of science curriculum are reflected in the textbook content and touches all aspects of scientific literacy mentioned by Bybee (1995) and Ramsey (1995).

As stated in the results, science content in the text books presently in use comprise of formal concepts (std.9 and to some extent, std.8) and concepts related to personal needs and societal issues (std. 10) in line with the tenets of scientific literacy namely that science education should be "an education about science" (Yager, 1984; Harms and Yager, 1984) and not "in science" as followed earlier in traditional curricula.

At the same time it is important to note that 'confinement' and compartmentalisation of material on formal concepts about physical, chemical and biological laws almost exclusively to one grade (std.9) and those on societal /ecological / technological issues exclusively to a different grade (std. 10) appears to 'negate' the purpose of 'integration and interdisciplinary' approach envisaged in the objectives. Added to this, **assessment** at the terminal examinations is done for individual grades restricting to the textbook content included and studied during that particular year and grade only, without a practical examination at any grade level. Thus continuity and balance between formal concepts and societal issues are lost. This could be one of the reasons for the teachers to view:

(a) material in grade 9 as 'real science' and that of the 10th std. as 'general

science'

- (b) that the curriculum is only partly useful for those who may pursue science further. This is at variance to the opinion expressed by Hofstein et al. (1990) that since all the learners may not pursue science at the higher level, it becomes imperative to meet the needs of both the science centred and non-science centred learners.

Results on analysis of the questionnaire show that in the teacher's opinion the content is relevant to the objectives, as they understand them. In their view, If the textbook content is completely learnt, then the objectives can be taken as achieved. This supports the observation made by Goodlad (1984) and Kumar (1992), that teachers view textbooks being synonymous with prescribed curriculum.

Examining the above responses of teachers in light of the tenets of scientific literacy and science education indicates that the problem may be more about presentation of content in terms of sequence, continuity, balance etc., rather than the intended curricular objectives.

#### **5.6.15 Presentation of Concepts**

##### **Sequence and Continuity of Topics**

Results show that both sequence and continuity have not been maintained across the grades. However, in grade 9, within each chapter formal concepts precede

abstract ones as suggested by Dove (1980). Topics (formal concepts in science) covered in the std. 9 content have no continuity nor are integrated with content in the std. 10 which entirely deals with societal or environmental issues. **Interdisciplinary** nature of science is also not reflected, as interrelationships among the different streams of science have not been touched upon. Majority of teachers categorise content in 9th and 10th standards respectively as **real** and **general** science and indicated their dissatisfaction with the continuity of topics across the grades. This needs to be remedied.

#### **5.6.16 Illustrations**

Results show that the illustrations are relevant, clearly labelled and adequate meets the requirement of curricular guidelines NCERT (1990). Only reproduction of photographs requires much improvement and if this is done, this aspect of curriculum can be considered to be very satisfactory. The teachers refer the learners to these figures and diagrams given in the textbooks instead of models and charts though available. They feel that unlike models or charts, which only can be demonstrated, all the learners have ready access to them through the textbook for use whenever they feel the need.

#### **5.6.17 End-of-Chapter Exercises**

Results show that the **questions are not open ended, applied or of the probing**

**type.** Teachers consider them adequate as they serve the purpose of recalling definitions, solving numerical problems, and assessment of the learners' mastery over the content. They do not seem to arouse learners' interest in exploring other sources for information or generating **critical thinking** in them which is one of the objectives of science curriculum. In this context addition of probing and application type questions to the exercises will be useful to the learners.

#### **5.6.18 Experiments and Practicals**

The analysis of content also indicated that the textbooks included simple experiments and activities, which could enhance the understanding of concepts as well as develop manipulative and process skills in the learners. However, a major drawback observed was that these activities were conclusive and not at all open-ended. In the teachers' opinion, as **full description** of the experiments with results are given in the content, these as well could be read without actually performing the tasks in the laboratory.

#### **5.6.19 Language**

Results reveal that opinion of the teachers is divided regarding the extent of understanding by the learners of the language style used in the textbook content. The opinion ranges from the remark that language used is simple, to saying that language style used for conveying concepts needs simplification. Obviously certain concepts need detailed explanation and it is left to the teachers to decide about the appropriate instructional strategy to be adopted.

#### **5.6.20 Role of Textbooks**

It has been seen above that textbooks play an important role in shaping classroom practices. Results show that the teachers relied on the textbook content to shape what constitutes “valid” knowledge in the classrooms and also as means of

controlling the classroom proceedings. Since in the teachers' view, textbooks represent the prescribed science curriculum (Goodlad, 1984; Kumar, 1992), they feel that their task is limited to a successful transmission of the given content.

Also, as the teachers put it, scientific knowledge being factual (in case of formal concepts), and unchangeable, they are of the opinion that the prescribed textbooks serve their purpose of teaching science adequately. The teachers also 'adhere' to the sequence as it appears in the textbook content and explanations are given in a textbook like language. It came to light that for the teachers, the **textbook symbolised a collection of lessons to be taught sequentially** as they appear and serve as a means to ensure learners' success in examinations. Studies about teachers understanding of the nature of science (Abell, 1989; Selley, 1989; Martin, 1990) have consistently indicated that most teachers perceive science as an 'empirical – inductive' enterprise. This is thought to be the consequence of 'picture' of science which emerges from the textbooks (Selley, 1989). Ideally it is expected that **textbooks would provide the link between the "established scientific fact" of a topic and the concrete level of evidential and experimental support** (Stinner, 1992) given to it. However, on content analysis, the science textbooks are seen to be inadequately equipped about dealing with conveying an appropriate understanding about the nature of scientific knowledge to both teachers and learners. It has been mentioned in the earlier sections about teachers'

pedagogic practices being contingent on their own experiences. This is again evident where teachers resorted to transact science by the way of established fact which is viewed as a finished product and mathematical formulations (Hewitt, 1990; von Bayer, 1990; Rigden, 1991) to be transmitted to students. This approach severely restricts the development of understanding in the learners about the nature of science contrary to curricular intentions.

It can be reasonably concluded from the evidence that the role of prescribed textbooks gets limited to using them as a means of ensuring students success at examination through rote application and memorisation (von Bayer, 1990; Hewitt, 1990; Stinner, 1990).

## **5.7 IMPLICATIONS FOR SCIENCE CURRICULUM**

A question that arises is whether one should look into the intended curriculum content for all the three grades (8th, 9th and 10th) together or should they be viewed as individual entities. Both the learners and teachers presently look upon these as independent entities, the reason being that once examination is over in one grade, the content for that grade can easily be forgotten since in the next grade, the questions at the annual assessment pertain only to the content given in the text books for that grade. However, even with the present curriculum content, curricular framers' intention of making the learners scientifically literate, can perhaps be realised only if assessment is done for the entire content (grades 8 to

10) included in the curriculum. Indirectly this means that either the assessment held at the end of the 10th grade should be based on the content for the three years together which may not be desirable or

- (i) the content could be distributed with equal weightage to scientific knowledge and technology-societal issues among all the three grades; If such a distribution is done even if the assessment is textbook centred, it takes care of the integration aspect of formal concepts and societal issues which is one of the intended objectives of science literacy;
- (ii) both the end-of-chapter exercises and the questions at the examinations should contain an element of application of knowledge already acquired but not solely to test how much the learner can recall the knowledge imparted both through the text book and the classroom transaction earlier; and,
- (iii) a few selected practicals to be made compulsory.

Textbook content being an important factor in implementation of curriculum, adding a glossary, reorienting the end-of-chapter exercises to include probing and application type of questions, and exercises to promote scientific attitude and temper in the learners should be considered. Science 'project work' is another area where the intended curriculum objectives are receiving less attention at the implementation stage in the classroom situation. Incidentally these steps may encourage learners to look up to additional sources for fuller appreciation of the topics being transacted to them which is not the situation at present.



Irrespective of the objectives mentioned in the curriculum documents considered significant for implementation of the goal of spreading scientific literacy at the secondary school level, the immediate concern of the teachers has been to stick to the textbook content and complete the syllabus and revise the content in time for the final examination at each grade. This was also evident when during this investigation, the teachers expressed that they are not clear about the implementation of objectives regarding science-technology-societal issues developing aesthetic, cultural environmental issues, which has been included in the 10th standard in schools in Gujarat.

An interesting point that emerges from this investigation is that teachers have a tendency to ***readily accept anything, which is part of textbook content*** in the context of both lesson transaction and assessment. In the present state of affairs, it can therefore be noted that anything that may be mentioned in the textbook content has more chance of being taken seriously by the teachers; if the content does not explicitly state about how a particular objective can be achieved, it has less chance of being realised in the class room transaction to the extent intended. In fact it appears that the nuances that differentiate the terminology-- scientific knowledge, scientific temper, scientific attitude and scientific literacy (scope and meaning) may have to be more precisely (spelt out in the guidelines and textbooks suitably) explained not only for the benefit of the learners but also the teachers.

It need not be reiterated that success of the learner at the examination covering the textbook content is virtually seen as a successful implementation of the prescribed curriculum by the teachers irrespective of the nature and means of classroom transaction or the extent of realisation of the intended curriculum objectives. Thus in the actual classroom transaction it may not be out of place to say that the textbook content takes 'precedence' over the 'intended objectives' contained in the official documents. The classroom observations reveal that teachers teach 'science' by transferring the 'information' in the textbooks to the learners through lecture method. The teachers assume that the content is written according to the intended objectives. As long as the textbook plays such a major role in curriculum transaction, it seems essential that the curricular objectives be more explicitly reflected in the textbook either directly or indirectly, at the same time, keeping in view the principal characteristics of a textbook.

Hence, any attempt to improve classroom transaction for better realisation of the curricular goals, one has to ensure that as many aspects of intended objectives get reflected in the textbook content, at the same time not burdening the learners. So, it is the text book content (rather, in the present context, what is the material that has to be included in the text book for realisation of intended objectives) that has to be gone through more intensively to see if all aspects which are helpful to the teachers and learners for implementation of the objectives have been included.

At least for selected topics as mentioned earlier, it may be desirable to provide instructions through the textbook even at cost of denying freedom to the teachers in the choice of instructional strategies. In a textbook centred transaction taking place in actual environment, this seems inescapable.

All these additions to the textbook may not ensure cent per cent curricular realisation in the real time classroom situation. But the observation in the present study that at least some teachers are making efforts towards implementing the relevant instructional strategies (discussion based (10%), and the activity based 5%), one can hope that with inclusion of some of the suggestions (by updating/ revision of) in the textbook content indicating clear directions in which the scientific literacy objective can be realised, this percentage may gradually increase since several schools do not seem to lack teaching aids or laboratory facilities.

Examination of the questions both at the end-of-the- chapter exercises, and in the question papers used for assessment clearly showed that *very little emphasis* is laid on *application of theoretical aspects* rather than on testing the recall capacities of what has been contained in the text book content.

Regarding *experiments* it has been noted that these are not open ended but fully described in the respective lessons. This is one of the reasons cited by the teachers for not conducting classroom demonstrations in the teaching strategy. In place of such a full description, for selected experiments it may be useful to explain these

in brief in a lesson and leave one or two probing questions for the learners to find for themselves by performing the experiment. This may need a blending of the curriculum objectives with the teachers perspective about the experimental details included in a lesson in view of the fact that textbook is the de facto curriculum under implementation.

Regarding *activity based teaching and practical work*, in place of practicals or project work, the teachers prefer to complete the text book content within the time frame available for classroom transaction; some of the teachers were *equating development of problem solving skills with that of solving numerical problems* by the learners.

These aspects need closer examination. Encouraging co-teaching or arranging demonstration of time management using this strategy within the 35 minutes available for a session involving the few teachers using appropriate instructional strategies may go a long way in improving class room transaction. Other ways and means also have to be found out how this approach to explanation of concepts could be extended to the majority of the teachers using activity-based instructional strategy.

In the content, laboratory experiments, for some reason, have been mostly confined to the syllabus for the 9th standard, but not spilled over to the tenth. As mentioned earlier, in the 10th standard, emphasis has been laid on societal and

environmental problems faced in the modern world without explicitly explaining what may have to be done to achieve the objectives in the curriculum content.

It is very interesting to note the fallacy that has been reflected in the results from this study that: *where the content has been fully loaded with transaction based on developing process and problem solving skills, (eg. grade 9th), the teachers were unable to implement it for lack of time, since covering the textbook content (formal concepts) with lecture method itself taking up most of the time in the classroom. Where the teachers find that topics are self explanatory (STS issues in class 10) they do not feel it essential to elaborate on these topics or assign simple project work, as they give full scope for self study.* This is also one reason for the suggested distribution of topics among the three grades in a suitable manner keeping the sequence, continuity and integrational aspects. This should receive priority for better realisation of the objectives.

It may be recalled that at several points during the present investigation 'lack of time' has been a common reason (apart from others) cited by the teachers for not following several of the appropriate instructional strategies though they were aware of them. The time available for a classroom session in the schools at Vadodara is 35 minutes of which 3-4 minutes are spent in movement from one classroom to the other. Introduction of lesson takes another 3 to 4 minutes and *teachers' talk goes on for 25 minutes* without student participation. At the most, in a few cases it was observed that student participation lasted for 2-3 minutes

while in others this was used to close the lesson. This has been the general observation. On the other hand, it is observed from the results that a few teachers have been using activity-based teaching strategy for a few lessons with an equitable time distribution (about 14-16 minutes each) for teacher-talk vs student talk. However, these teachers also expressed the view that they had to limit this exercise only for a few topics due to paucity of time. Thus time distribution has to be given due importance in framing the curriculum so that the intended objectives can be realised to a greater extent.

In the context of availability of time and the results obtained from observation of classroom transaction, the following questions arise:

Is the method of introduction of the lesson currently being followed in the schools adequate and satisfactory as per the objectives envisaged in the curriculum

Is it necessary and feasible to broadly classify / categorise lessons or topics into:

- (a) those, that can be written on blackboard, with one or two simple questions and directly proceed with the lesson further through lecture method
- (b) those that need to be introduced with appropriate assessment of the students response by the teachers to previous day's lesson
- (c) those that essentially need an activity or demonstration or project work
- (d) Is there not a need at the time of framing of curriculum to pay attention to

this aspect in transaction in relation to

the method of instruction (teaching strategy) and

time allotment for the teacher vs. learners talk in relation to:

the method of introduction and

time allotment for introduction

time allotment for the rest of the lesson

time allotment for teacher-pupil interaction

Thus ultimately, in any future revision, topic vs. mode of teaching vs. possible time likely to be spent for its transaction in the expected mode, redistribution of concepts and STS issues among all grades 8 to 10, inclusion of selected experiments for practical examination, and project work on simple topics on STS issues need attention of the curriculum framers. The content may also have to be limited to a lesser number of topics, so that each mode of transaction appropriate to the lesson gets its share of time. This requires further deliberation at proper forums and beyond the scope of the present investigation.