# CHAPTER IV

# THEORY AND PREPARATION OF THE ATL MODEL

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# CHAPTER - IV

# THEORY AND PREPARATION OF THE ATL MODEL

## 4.0. Chapter Preview

This chapter deals with the different stages involved in the development of ATL Model. It describes the analysis of the existing theories and models of learning which forms the base for the development of the model. Theories and principles related to constructivism, experiential learning and reflective learning are discussed in detail. The main strategy used for the present study is field study of industries. The chapter presents the reports of the field studies conducted, the outcomes of these studies and the preparation of the ATL Model based on the outcomes of the studies.

## 4.1 ATL Model – The Theoretical Base

### 4.1.1 Introduction

Modern pedagogy is moving increasingly to the view that the child should be aware of her own thought processes, and that it is crucial for the pedagogical theorist and the teacher alike to help her to become more metacognitive. Achieving skill and accumulating knowledge are not enough. The learner can be helped to achieve full mastery by reflecting as well upon how she is going about her job and how her approach can be improved. Equipping her with a good theory of mind – or a theory of mental functioning – is one part of helping her to do so (Bruner, 1996).

A theory of instruction in teaching is concerned with how, what one wish to teach and how one can best learn. Traditional approaches within education lead to fall into two camps, the didactic, passive model which emphasizes drill and rote memorization, and whose idea of independent study consists of library research and the so called discovery learning approach which encourages simulations, experiments and independent research in a natural environment (Rushby, (1987). The latter focuses the student to take an active role in the learning process whereas the former demands only a passive ingestion of information and knowledge.

The traditional concepts that view technology as a delivery vehicle or instruction controller only, must be challenged. New strategies that embrace the view of technology, as a facilitator of thinking and knowledge construction must be developed. According to Jonassen (1995), the most meaningful and productive uses of technology engage learners in:

Knowledge construction, not reproduction;
Conversation, not reception;
Articulation, not repetition;
Collaboration, not competition; and
Reflection, not prescription.

The role of teachers is primarily to facilitate 'an active construction by pupils within a social context' (Martyn, 2000). This can be done by organizing and directing experiences which are matched with pupils' abilities and attainments. Pupils can also construct meaning from simplified experiences involving actions and consequences. The most natural way to learn is through an apprenticeship type of environment where learning takes place in the context of doing (Anderson et al, 1984). There is greater emphasis on learner control (Duchastal, 1986) and adaptation to the learner's existing knowledge. Duchastal (1986) calls this a reactive learning environment.

Thus three areas of pedagogy may be identified (Mortimore, 1999) that are of equal importance to learning:

**1. Instructional techniques**

*Creating learning environments*

organizing materials/resources

providing relevant/interesting and novel experiences

providing opportunities for active exploration

questioning

*Direct instruction*

demonstrating

describing

answering questions

directing the child's attention

constructive criticism and reinforcement

*Scaffolding*

directing attention to a new aspect of a situation

helping the child to sequence activities

managing complex tasks by breaking them down into manageable components.

**2. Encouraging involvement**

The teacher may act as a role model, expressing his or her own interest and enthusiasm for the subject and encourage the children to recognize the 'validity' of what they are doing by communicating beyond the classroom.

**3. Fostering engagement**

Activities need to be matched to the child's capability. Knowledge of the child's current development is therefore crucial.

Taking in view the above mentioned approaches, the investigator proposed to prepare a model for learning in an apprenticeship-type of environment. For this she made an analysis of the theories and models of teaching and learning, related mainly to cognitivism, constructivism and experiential and reflective learning, the details of which are presented below:-

### 4.1.2 Cognitive theories of learning

For cognitive psychologists, learning is viewed as a constructive process where changes occur to the internal representation of knowledge (Wildman, 1981). Instead of learning responses, the emphasis is on learning information (Low, 1981; Shuell, 1987). Cognitive learning theorists proposed "explanation for learning that focuses on the internal mental processes people use in their effort to make sense of the world (Eggen and Kauchak, 1994).

According to Jean Piaget and his disciples, memorized knowledge was not real or useful in that it generally could not be applied to genuine problems in life's experiences. Piaget maintained that knowledge, and even intelligence must be uncovered and constructed through intensively personal activity by the child. Piagetians theorized that young humans have two basic strategies for interacting with their surroundings: assimilation, where they absorb experiences into already formed but evolving cognitive structures and accommodation, where they modify existing cognitive structures to deal with discrepant experiences. Piaget pointed out that much learning occurs without any formal instruction, as a result of the child interacting with the environment.

For Piaget, teaching should create situations in which children can develop mental structures or ways of organizing their concepts of reality. Teachers should encourage children to explore and experiment. They should be provided with concrete materials to touch, manipulate and use. The learner then relates the newly met concept to the pre-existing cognitive structures. Knowledge and skills acquired during one stage of cognition form the basis for the knowledge at the next stage. In this pupils' prior conceptions become an important factor in their understanding and therefore their prior ideas and assumptions and their willingness to use them have to be considered as a starting point for effective teaching.

Ormrod (1995) summarizes Piaget's basic assumptions about children's cognitive development in the following way:

- ★ Children are active and motivated learners.
- ★ Their knowledge of the world becomes more integrated and organized over time.
- ★ Children learn through the process of assimilation and accommodation.
- ★ Cognitive development depends on interaction with one's physical and social environment.
- ★ The process of equilibration (resolving disequilibrium) helps to develop increasingly complex levels of thought.
- ★ Cognitive development can occur only after certain genetically controlled neurological changes occur.
- ★ Cognitive development occurs in four qualitatively different stages.

New ideas from cognitive science propose the importance of "anchoring instruction" in activities that students find meaningful and "authentic" (e.g., related to real-life situations) in the context of their own experiences. The CTGV (1990) described "anchored instruction" as that is "situated in engaging problem-rich environments that allow sustained exploration by students and teachers". Proponents of these theories say that students who learn skills in isolation from such real-life problem solving will not remember to apply this pre-requisite information when they require it. They recommended anchoring instruction in situations where students not only create answers to problems but also generate many aspects of the problem statements themselves.

Anchored instruction creates environments that permit sustained exploration by students and teacher, enabling them to understand the kinds of problems and opportunities experts in various areas encounter and the knowledge that these experts use. One way to plan for anchored instruction is to use problem-based or problem-centered learning. A problem-centered curriculum is one that is built around the solution to a real-world problem of interest. Placing the problem at the center emphasizes students' "doing" rather then their mastery of discrete pieces of information or skills. Once a design for learning has been anchored in a problem, students must be challenged with appropriate activities that support and direct their ability to solve problems in a robust and comprehensive manner.

Anchored instruction provides a way to recreate some of the advantages of apprenticeship training in formal educational settings involving groups of students. Thus cognitive theories stress the importance of learning in a natural environment. Experiences acquired by interacting with the environment contribute a lot to the acquiring, processing and retrieving of information. The development of ATL Model also aimed at learning through experiences in a natural environment.

#### 4.1.2.1 Information processing

Information processing can be thought of as “the way people gather and organize information from the environment in order to form useful patterns which can be used to explain and predict events in there experience (Eggen & Kauchak, 1988). The goal may be achieved by students’ active investigation of there environment and through the analysis of data gathered from that environment. This idea is based on a movement in psychological thinking which views the learner as an active investigator of the environment rather than a passive recipient of stimuli and rewards.

Information processing models are teaching strategies based on information processing theory that are designed to help students learn content at the same time as they practise thinking skills under the guidance and direction of an active teacher.

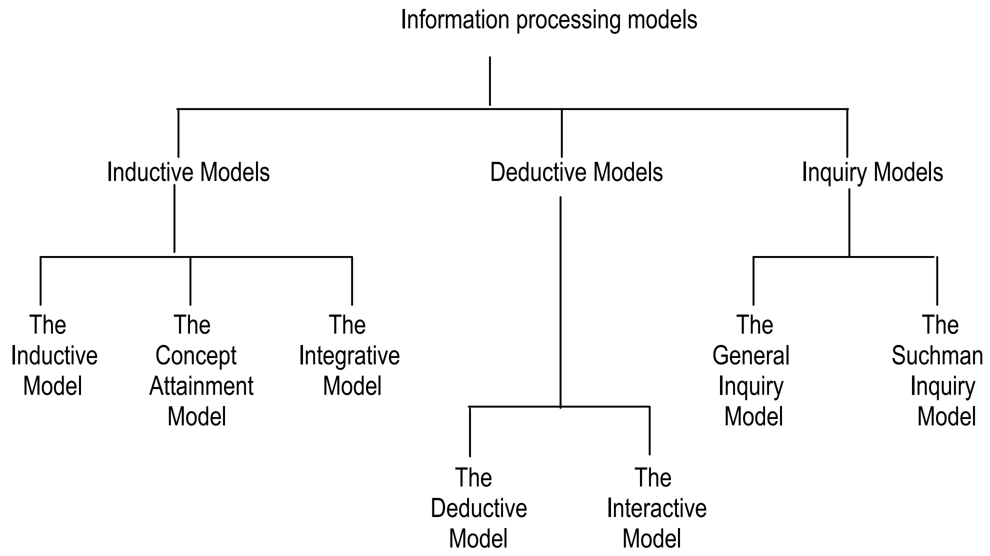



***Figure 4.1*** ***Information processing models***

An information processing approach to learning stresses the importance of meaningful, purposeful learning versus rote memorization of content (Smith, 1975). Information processing that emphasizes the meaningfulness of the material being learned and the integration of new material into presently existing schemas is superior to rote approaches to learning (Gage & Berliner, 1984; Rosenshine & Stevens, 1986). An idea is considered meaningful to the extent that associations can be made with it and other ideas. The more the associations that can be made, the more meaningful the idea is. Hence information processing involves a dual and inextricable relationship that involves the acquisition of organized bodies of knowledge and the intellectual skills necessary to learn independently.

The information processing views on learning have become the basis for many common classroom practices. Gagne (1985) proposed that teachers use a hierarchical "bottom-up approach", making sure that students learn lower-order skills first and building upon them. Ausubel, by contrast, recommended a "top-down" approach; he proposed that teachers provide advance organizers or overviews of the way information will be presented to help students develop mental frameworks on which to "hang" new information (Gage & Berliner, 1988).

New perspectives of learning offers a central place for both thinking skills and knowledge and also give appropriate recognition to the domains of attitudes, creativity and applications. Psychology in general and information processing specifically provide one valuable framework for addressing the development of students' thinking skills and abilities (Steinberg, 1985) as shown in Figure. 4.2.

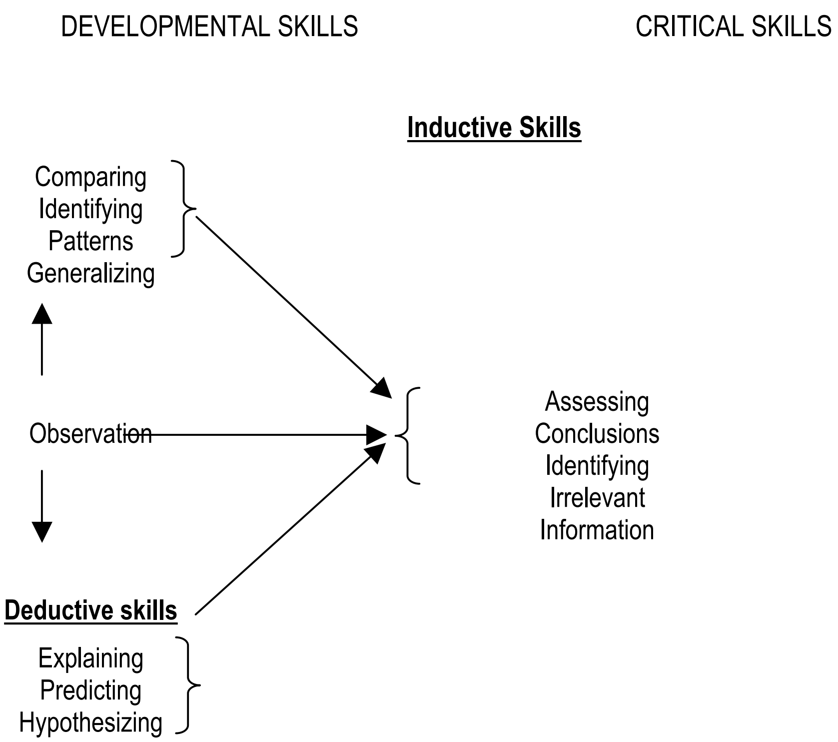



**Figure 4.2 Thinking skills**

The Cognitive Acceleration through Science Education Model (Adey & Shayer, 1994) is a strategy, which encourages the development of higher order thinking skills in students. The model helps the children to collectively explore advanced concepts and then discuss and reflect on what they have learned. It uses a set of 32 special 'thinking science' activities along with a lot of other materials, which includes comprehensive documents of curricular materials, OHT (overhead transparencies), video cassettes of illustrated activities etc., which are developed utilizing the neo-Piagetian concepts.

Gagne (1985) used information processing model of internal processes to derive a set of guidelines that teachers could follow to arrange optimal "conditions of learning". He built on the work of the behavioral and information processing theorists by translating principles from their learning theories into practical instructional strategies that teachers could employ with direct instruction like events of instruction, the types of learning and learning hierarchies.

Information-processing models of learning tend to have three elements, two of which overlap with constructivists models: a firs stage in which, through selective attention, certain aspects of the environment are filtered for conscious processing; a second, in which active mental engagement with the new input occurs so as to make personal sense of it, using selectively recalled prior learning in the process; finally a structuring of the resultant learning in such a way that it can be stored usefully in the long-term memory (Atkins et al, 1992). Thus, as with constructivist models, knowledge is seen as an entity, something cohesive and holistic which then provides a scaffolding for later learning.

In addition to the information processing model for acquiring knowledge, four models of the learning process would seen to have particular relevance to Analyzing Educational Programme (ALP). These may be categorized as follows:

1. Learning is a product of acquiring skills. This approval is exemplified by the work of Skinner (1968)
2. Learning by the gradual development of more complex modes of learning. This differs from the "skill" model in postulating a hierarchy of techniques gradually acquired by children in the course of their intellectual development. This model has been used by Gagne and to a limited extent by Piaget. Many expert systems have made use of this model.
3. Learning as a continual process of developing and made flying conceptual frameworks (or scripts). This model also has been used

by Piaget and is now being incorporated into work on Certified Intelligence (Schank, 1982).

4. Learning as a feed back process in which the learners' responses are modified by perception of pervious performance. This model has been adopted mainly by psychologists investigating motor skills involving timing.

### 4.1.3 Constructivist learning perspectives

Historically, educators have explained learning by classifying it into one of three broad categories - transmission, maturation, and construction (Trowbridge & Bybee, 1996) as given in Figure 4.3.

| Perspective | View of Students | View of knowledge | Approach to Teaching |
|---|---|---|---|
| TRANSMISSION | They must be filled with information and concepts. | Core concepts are a copy of reality | External to Internal |
| MATURATION | They must be allowed to mature and develop | Emergence of core concepts | Internal to External |
| CONSTRUCTION | They are actively involved in learning | Construction of core concepts | Interaction Between Internal and External |

**Figure 4.3** **Perspectives on education (Trowbridge & Bybee, 1996)**

Piaget (1978) theorized that children construct their own understanding on the basis of their explorations and interactions with peers, adults and objects within their environments and come to know an object by acting on it. Present day cognitive scientists adopt from Piaget a constructive view of learning, postulating that humans are not passive recipients of knowledge but active constructors of knowledge structures.

Receiving information is not truly learning; the information must be placed in perspective, interpreted, and related to other existing knowledge in the brain's memory structures. Skill in mastering a scientific process requires more than just mechanically performing a procedure; but also knows when to perform it and how to perform it and how to modify it or adapt it to unique situations.

Constructivism is a dynamic and interactive conception of human learning. Students redefine, reorganize, elaborate, and change their initial concepts through interaction between the individual and the environment and other individuals. Individual learners interpret objects and phenomena and internalize the interpretation in terms of current concepts similar to the experiences being presented or encountered. If a current conception is challenged, there must be opportunity to reconstruct a more adequate conception than the original. In short, the students' construction of knowledge can be assisted by using sequences of lessons designed to challenge current concepts and provide opportunities for reconstruction to occur.

Constructivism rests on four central tenets (Fosnot, 1989).

First, knowledge depends on past constructions. We use our mental frameworks to transform, organize and interpret new information. This mental framework is constructed and evolves as we interact with our environment and attempt to make sense of our experiences.

Second, constructions come about through systems of assimilation and accommodation.

Third, learning is an organic process of invention, rather than a mechanical process of accumulation. Learners must be provided with experiences of hypothesizing and predicting, manipulating objects and data, researching answers, imagining, investigating and inventing in order to construct knowledge.

Fourth, meaningful learning occurs through reflection and resolution of cognitive conflict, negating earlier, incomplete levels of understanding. Teachers can only mediate in this process.

Constructivism has four major principles:

1). Learners do not passively receive and store information in their minds but actively create meaning from construction of concepts about reality;

2). Though learning is shaped by a person's prior knowledge, this knowledge is being continually reconstructed;

3). The construction of new knowledge – new ideas and concepts – is located in the social situations in which it is acquired;

4). Learning involves a process of social interaction with others.

Constructivists favour an activity-centred curriculum in which students actively (mentally and physically) interact with knowledge to construct meaning for themselves. Constructivist instruction features interactive learning experiences in which students often work collaboratively to revise and expand their knowledge base. During a constructivist learning experience, students have opportunities to become aware of their pre-existing ideas – they interact with materials, observe and then verbalize their inherent existing explanations for a phenomenon. Then they test and scrutinize their explanations, often modifying then and then sometimes abandoning them.

Implementing the constructivist view requires:

(1) teaching in a manner that recognizes the students' level of conceptual understanding and

(2) an understanding that the students' construction of knowledge occurs through the confrontation and resolution of problem situations. The key here is that confrontation should be challenging but within students' parameters of intellectual accommodation.

Recent works in cognitive and constructivist psychology shows learning in terms of networks with connections in many directions; not as an external map that is transposed directly into student's head. Rather it appears to be part of an organic process of reorganizing and restructuring as the student learns, suggesting that learning is a process of knowledge construction (von Glasersfeld, 1987). Learning occurs not by recording information but by interpreting it, so that teaching is seen not as direct transfer of knowledge but as an intervention in an ongoing knowledge construction process (Resnick, 1989). Thus in constructivist learning theory students learn by actively making sense of new knowledge, making meaning from it, and mapping it into their existing knowledge map or schema.

Social constructivism, as embodied in the work of Vygotsky (1978), sees culture as important in accounting for human action and cognition within social practices (Lave, 1988). In education this has led to a strong emphasis on the importance of the context of learning (Tharp & Gallimore, 1988), the notion of cognitive apprenticeship and the ability of children to learn in communities with adults (Rogoff, 1990).

A constructivist model of learning begins with an active and engaging process that provides an opportunity for the learner to create meaning from an experience. The students reconstruct core concepts, or intellectual structures, through continuous interactions between themselves and their environment (which includes other people).

Traditional models are highly prescribed, externally directed, content driven and represent a view of knowledge as external to the learner while constructivist learning requires the kinds of flexible learning environments created when teachers provision their classrooms with tools that prompt students to organize and create knowledge (Norton & Wiburg, 2003).

Applying the constructivist approach to teaching requires the teacher to understand that students have some conceptions or prior knowledge of the world. Such conceptions may be inadequate (i.e., conceptual change). In teaching for conceptual change, teachers should be sure that students are focusing on objects or events that engage concepts of interest to the science teacher. That is, they are related to science or technology. Then, students can encounter problematic situations that are slightly beyond the current level of understanding. In so doing, the student will experience a form of cognitive disequilibrium. Teachers then structure learning experiences that assist the reconstruction of core concepts. New constructions can be applied to different situations and tested against other conceptions of the world.

Constructivists call for more emphasis on engaging students in the process of learning than on finding a single answer and propose arranging instruction around problems that student find compelling and that require them to acquire and use skills and knowledge to formulate solutions.

The goal may be achieved by students' active investigation of there environment and through the analysis of data gathered from that environment.

Students can be made active participants in the learning process by exploring the methods at the beginning of a topic to generate interest, then visiting locations outside of school to allow students to learn the experts' tricks of the trade (heuristics) followed by discussions that allow further development of both knowledge and learning skills (Ashman & Conway, 1994).

Thus constructivist learning models tend to:

i) Focus on learning though posing problems, exploring possible answers developing products and presentations.

ii) Pursue more global goals that specify general abilities such as problem solving and research skills.

iii) Stress more group work then individualized work.

iv) Emphasize alternative learning and assessment methods: exploration of open-ended questions and scenarios, doing research and developing products, assessment by student portfolios, performance check lists and tools with open ended questions; deceptive narratives written by teachers.

Instructional needs addressed primarily by constructivist model are

i) making skills more relevant to students' backgrounds and experiences by enclosing learning tasks in meaningful, authentic (e.g. real-life), highly visual situations,

ii) addressing motivation problems through interactive activities in which students must play active rather then passive roles,

iii) teaching students how to work together to solve problems through group based, co-operative learning activities and

iv) emphasizing motivational activities that require higher level skills and pre-requisite lower-level skills at the same time.

The constructivist theory and models of teaching provided a strong base for the development of ATL Model. Activities involving direct experiences are highly inquiry-oriented. Since students are involved in 'real life' events, they are motivated to be active participants and they will learn to construct meaning out of their experiences. There are more opportunities for exploration than when other media and symbols are used as surrogates for the real event. The students can discover for themselves the many facets of the experience and take from it more than what is intended. The 'doing' activities will provide concrete referents for future activities of a more abstract nature.

### 4.1.4 Experiential Learning

Learning is an active process in which meaning is developed on the basis of experience (Duffey & Jonassen, 1992). Experience determines the directions in which instinct may profitably be expressed. It includes an active and passive element peculiarly combined. On the active hand experience is trying, a meaning which is explicit in the connected term experiment. On the passive, it is undergoing. When pupils experience something, they act on it, they do something with it, and then they suffer or undergo the consequences.

As action becomes more complicated and the environmental aspects become more complex, confusion results and interpretation becomes difficult. When interpretation involves the resolution of doubts or hypotheses by making further observation, by more action, we have 'reflective experience' or reflective thinking. Out of experience or additional activity of one sort or another, inferences arise that are tested by further action. It is said, then, that a 'reconstruction of experience has taken place'. This is undoubtedly the highest type of learning.

Experiential learning differs from conventional learning in several extremely important aspects. It stresses giving the children a multiplicity of experiences, rather than instructing them by lecturing or reading. It involves stimulating them to thought and action (Karlin & Berger, 1971). Through these students will be encouraged to work intellectually and often physically as well.

According to Dewey (1916), education "is that reconstruction or reorganization of experience which adds to the meaning of experience and to which increases ability to direct the course of subsequent experience". His approach - a "hands-on" or process-oriented approach - to learning emphasized activities and processes by which children interacted with their environment. He identified three levels of activity where learning moves from simple impulses to careful observation of the environment, to planning actions and finally to reflecting on and testing the consequences of action.

His method provides continuity between children's world of direct experience and a school curriculum that arises from and develops that experience. Because of this continuity, students readily become interested and motivated, eager to pursue their interests into areas of broader educational importance.

Learning is not usually an outcome of formal training. Instead it comes from a process of self development through experience (Thompson et. al, 1995). Learning is about developing oneself. Pupils learn best when they are in control of the learning process, rather than receiving a lesson or subjected to teaching. Not all modes of instruction are able to do this. Participants learn best when they are actively involved and motivated.

Oliver (in Evans and Nations, 2000) analyses five prominent ways by which we can provide learning experience to students.

1. *Students-centered mode of teaching*: where the teachers play a facilitating role supporting learner autonomy and self-regulation.

2. *Constructivist environment*: providing students with active engaging learning experiences, which enable them to construct personal understanding to the content, i.e. learners are active architects of their own knowledge.

3. *Problem-based learning*: where learning occurs through a systematic inquiry of tasks and problems with 'solution spaces' within the academic content.

4. Situated learning : wherein learners are exposed to the content in realistic and authentic setting and the learning activities reflect the way in which the knowledge is intended to be used in real life.

5. Collaborative learning: in which the learners develop knowledge and understanding of content through interactions and joint activities with other learners.

Kolb (1984) suggested that there are four different kinds of abilities that learners need if they are to be effective. They must be able to,

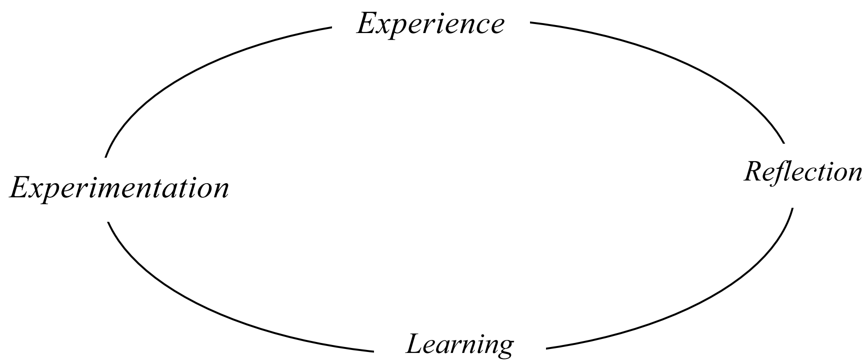
- involve themselves fully, openly and without bias in new experiences: concrete experience.
- reflect on and observe these experiences from many perspectives: reflective observation.

- concrete concepts that integrate their observations into logically sound theories: abstract conceptualization;
- use these theories to make decisions and solve problems: active experimentation.

The CTGV (1991) believes that learning is most meaningful to students when it builds (eg., scaffolds) on experiences they have already had. Students are also more likely to remember knowledge that they build or "generate" themselves rather then that which they simply receive passively. The CTGV felt that teachers could meet the criteria for situated cognition by anchoring instruction in highly visual problem solving environments.

The philosophy of experiential learning has been widely endorsed in the literature on learning in work-based contexts. It has generally led to teaching strategies – in schools, colleges and the best company programmes – designed to help students/apprentices 'capture' the essence of their work-based experiences (Fuller, 1996). The different traditions of learning in work-based contexts have all tended to see experience as the key source of learning. Further, experience has also been seen as the central means by which students acquire worthwhile knowledge and skill about the world of work.

Kolb (1984) developed an experiential learning cycle (shown in figure 4.4.), derived from the work of Dewey, which provides a more sophisticated, theoretical framework for understanding the challenge of learning in work-based contexts.




**<u>Figure 4.4</u>. Kolbe's learning cycle**

As Boud et al. (1993) have noted, the conception of experience that lies at the heart of pedagogies of experiential learning, including learning in work-based contexts, is rooted in a rational/positive epistemology in which experience is constructed as being transparent and giving students unmediated access to the world. From this perspective, knowledge of the world of work is deemed possible because it is assumed that there is a direct correspondence between the world and the way it is represented in the student's experience.

Learning on the job is viewed as on ongoing way of life which is challenging, exciting and personally constructive (Guile, 1995). Learning on the job offers a rich environment for generating diversity and change. Each and every experience allows us to construct personal meanings, made up of thoughts and feelings which underlie all our anticipations and our actions.

It is good teaching to prepare the way for probable experiences and to let the children learn thereby. Classroom experiences should not be purely intellectual. It should be enriched by practical elements, joyous feeling and pure sentiment, free expression and cooperative activity. For this it is necessary to establish a climate for experiential learning, stressing self control and responsibility. Students should be involved in planning and selecting their experiences with care. The teacher should remain the figure of authority, guiding and supervising. The world of work can provide pupils with this kind of learning experiences. Since the world of work cannot be brought into the school room, the school must go out to the world of work.

An apprentice learns much from his experience from the workshop, yet the workshop itself has been constructed in the light of definite aims and purposes. Thus learning by experience implies learning from the pressure of practical situations or environmental conditions in which pupils find themselves. The role of teachers is primarily to facilitate this by organizing and directing experiences which are matched with pupils' abilities and attainments. Such learning is best described as an active construction by pupils within a social context.

Martin Jr. et al (1988) suggests some classroom atmospheres which complements teaching roles and approaches to instruction, i.e. sheltered-experience-oriented classes and experience-oriented classes. Sheltered-experience oriented classes make 'use of learning aids like simulations, educational games, role playing, laboratory experiences, apprenticeships and practices'. Experience-oriented classes make 'use of on-the-job learning opportunities, school-work study programmes, field experiences and internships for life experiences'.

The development of the ATL Model finds its base on the above mentioned concepts to a great extent.

### 4.1.5 Reflective level teaching/learning

It has its root in the cognitive field theory of learning. The theory called goal insight theory, opposed the traditional mechanical memorization and meaningless understanding of the facts. It gave emphasis on the purposeful, goal directed insightful approach to learning and tried to make the learner learn the art and skill in problem solving behavior by identifying his goal and problem and learning to solve the problem in a scientific way.

Reflection is "intellectual and affective actions in which individuals engage to explore their experiences in order to lead to new understandings and appreciations”. It may take place in isolation or in association with others (Boud et al, 1985). Reflection on what has been learned from past lessons can be used to inform current learning or planning. Reflection during the lesson is called ‘reflection-in-action’ (Schon, 1983). Reflection after a lesson is called ‘reflection-on-practice’. It occurs after the event when the teacher or learner looks back on what has happened. The different types of reflection blend into each other, forming continuous cycles of reflection-and-action as teaching or learning progresses.

Reflection-on-practice is not just about learning from experience in a private and solitary way; it is about knowledge production that has the potential to enlighten and empower learners. In this sense it is a creative process. It can help teachers and learners envision, nourish and imagine improved teaching learning situations. Thus reflection is thinking again about teaching and learning. ‘Thinking again’ conveys the idea that reflection-on-practice needs to be seen as a continuous process of knowledge construction.

In this method the learners participate actively and develop insight into problems. Reflective level teaching requires free discussion. The pupils who are highly motivated are those who use the reflective method. They show a marked gain in critical insight and use their learning from out of classroom learning experiences. The procedures involved in reflective learning enhance a better learning atmosphere for the students.

Teaching situations may be classified according to where they fall on a continuum of learning objectives and learning conditions and it ranges from thoughtless to thoughtful mode of operations in teaching. The total range of teaching operations is divided into three broad classifications or levels arranged in the hierarchical order as given in the figure.

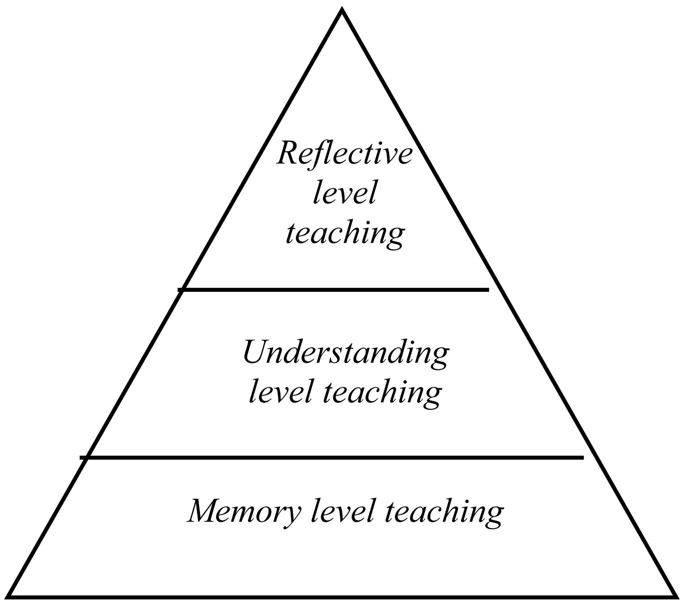



**Figure 4.5** **Levels of teaching**

Thus classroom teaching at reflective level requires students' active participation, critical thinking, creativeness and imagination. The students and the teacher co-operatively work to find out the solution of a problem which they face. Reaching an inference or conclusion by sound judgement is a good sense and logical build up of the collected information is an important aspect of reflective learning.

Majority of the methods now adopted in the classroom neglect the mental abilities such as scientific observation, conceptualization, inquiry, hypotheses formation, logical reasoning etc., which are important in reflective learning. But these traits can be developed by reflective questioning based on outdoor learning activities and experiences which enhance critical thinking and arriving at conclusions in a meaningful way. The development of ATL Model aims providing students with opportunities for reflective learning based on outdoor learning activities and experiences.

### 4.1.6 Learning theories associated with direct instruction

Direct instruction, is grounded primarily in behaviorist learning theory and the information processing branch of the cognitive learning theories. A few technology applications (eg., drill and practice, tutorials) are associated only with direct instruction; most others (e.g., problem solving, multimedia applications, telecommunications) can enhance either direct instruction or constructivist environments, depending on how teachers integrate them into classroom instruction. It is important to recognize that both direct instruction and constructivist approaches attempt to identify what Gagne (1985) would call the "conditions of learning" or the "sets of circumstances that obtain when learning occurs". The theories associated with direct instruction are,

**i). Behavioral theories**

Concentrating on immediately observable (thus, 'behavioural') changes in performance (e.g. tests) as indicators of learning. Skinner (1968) concentrated on cause-and-effect relationships that could be established by observation. To him teaching was a process of arranging contingencies of reinforcement effectively to bring about learning and even high-level capabilities as critical thinking and creatively could be taught in this way. Many of his principles led to the development of effective classroom management techniques (Sultzer & Mayer, 1972).

Behaviorists reasoned that teachers could link together responses involving lower-level skills and create a learning 'chain' to teach higher level skills the teacher would determine all of the skills needed to lead up to the desired behaviour and make sure students learned them all in a step-by-step manner. When the absence of pre-requisite skills presents a barrier to higher-level learning, direct instruction is usually the most efficient way of providing them.

**ii). Information processing theories**

Focusing on the memory and storage processes that make learning possible. Theorists in this area explored how a person receives (senses) information and store it in memory, the structure of memory that allows the learning of something new to relate to and build on something learned previously and how a learner retrieves information from short-term and long-term memory and applies it to new situations.

### 4.1.7 Models of teaching and learning

The models are fundamental to learning - in organizing ideas in such a way as to be able to predict effectively from experience. To predict the future on the basis of experience, the individual must store information in some structural way that corresponds to his environment. Bruner (1966) considers this to be the essential process of learning and suggests that one way in which the individual can translate his experience is manipulation and action (enactive). The most important aim of any model of teaching is to improve the instructional effectiveness through an interactive atmosphere. An effective model can be useful as a basis for an action.

Modelling can hardly be described as a straight forward activity because problem specification, observation, classifying, identifying relevant factors, hypothesizing, choosing assumptions, interpreting and other sub processes are mutually related and driven by the aims and underlying interests of the modeller. Evaluation takes place throughout the whole process (Houston et al, 1997).

The models approach to teaching recognizes the importance of three components the teacher, the student and the subject matter (knowledge, skills or attitudes) and integrates them into a decision making framework based on the three factors. Each of the component influences the form or shape of the teaching act (Eggen & Kauchak, 1988). It is grounded in the premise that an optimal strategy can be selected only when each is considered.

Joyce, Weil and Showers (1992) describe all the models in a formal pattern with five distinct components namely,

1) Syntax – the sequence of activities in the model,
2) Social system – the roles of, and the nature of relationship, between teachers and students,
3) Principle of reaction – the nature of reaction and attitude of the teacher to students' responses and behaviour,
4) Support system – the additional materials required for the models in addition to the human resources and
5) Effects – the implications of the model, both direct (instructional) and indirect (nurturant).

Teaching models provide the learning experiences by creating appropriate environment for real behavioural outcome. These follow scientific and systematic procedures to modify the behaviour of learners based on certain assumptions. All models of teaching specify the learning outcomes in detail on observable students' performance and mechanism that provide the students' reaction and interaction with the environment.

The reconceptualization of learning as a social process points to the need for new pedagogic models for supporting learning in work-based contexts. (Resnick, 1987) suggests that learning in formal educational contexts (i) is an individual process, (ii) involves a purely mental activity based on the manipulation of symbols and (ii) results in the production of generalized concepts. Learning in work-related contexts is, by contrast, a collaborative process leading to highly context-specific forms of reasoning and skills. She has summarized the differences between learning in and outside institutions as given below:

**Table 4.1**

**Differences between learning in and outside institutions (Resnick, 1987)**

| Learning in institutions | Learning outside institutions |
|---|---|
| decontextualized | has 'real' content |
| second –hand | first-hand |
| needs motivating | comes easily |
| tends to be individualistic | is co-operative/shared |
| assessed by others | self-assessed |
| formal structure | few structures |

Thus learning in work-related contexts is multi-functional and can provide students with an opportunity

- to enhance the links between their programmes of formal education and training – either in vocational education and training or in general education – and real work contexts,
- to acquire occupationally-specific skills, economic and industrial awareness and the development of generic competences and skills and
- to become lifelong learners through broadening the basis of their experience.

In the case of apprenticeship, it has been acknowledged that the emphasis on experiential learning has rarely led to any fundamental rethinking of pedagogy but has served only to reinforce the tradition of 'learning by doing' (Heikkinen, 1995; Rainbird & Ainley, 1999). Neither has it led to the development of new theoretical and conceptual frameworks with the purpose of relating apprentices' learning in work-based contexts to programmes of formal education and training (Gherherdi et al., 1998). This shows the necessity of a functional model, for learning in work-related contexts incorporating apprenticeships and work experience, which can provide the context for 'deep' learning as opposed to 'surface learning' (Ramsden, 1992).

Griffiths et al (1992) suggested five models for learning in work-based contexts. The models are analytical rather than descriptive and are as follows:

**Model 1** **Traditional model: the 'bridge into work'** –suggests a technical-rational perspective of work-based learning. The role of formal learning is to acquire knowledge and skills and the role of work-based learning is directed towards learning tasks.

**Model 2** **Experiential Model** – represents an attempt to reform the traditional model in response to the need for students to acquire less occupationally specific knowledge and skills and more generic knowledge and understanding about the content of work. The role of formal learning is to familiarize students with occupational changes and to develop their economic and industrial awareness. The role of work-based learning is to undertake activities to acquire an awareness of economic and occupational change.

**Model 3** **Generic model: Key skill/ Competence development** – based on slightly different principles than the traditional model which emphasizes using work-based experience to acquire learning outcomes (accreditation of knowledge, skills). The role of formal learning is very limited; competent work-based activity is all that is required and workplace learning is the major source of evidence for accreditation.

**Model 4** **Work process model: facilitated learning-** seeks to combine the emphasis in the traditional model on the role of the teacher with the commitment to self-management and self-development of models 2 and 3. The role of pedagogy is to facilitate the process of reflection-in-action but not necessarily reflection-on-context. The role of work based learning is to provide an opportunity to develop work process knowledge and the role of formal learning is to support that.

**Model 5** **A connective model of pedagogy and learning in work-based contexts** – based on a 'reflexive' theory of learning (Guile and Young, 1999b). It accepts that any form of learning is 'situated' (Lave and Wener, 1991) and also assumes that learning involves the use of concepts which may or may not be external to the context. The pedagogic task is to allow learners to conceptualize their experiences in different ways and for this conceptualization to serve different curriculum purposes.

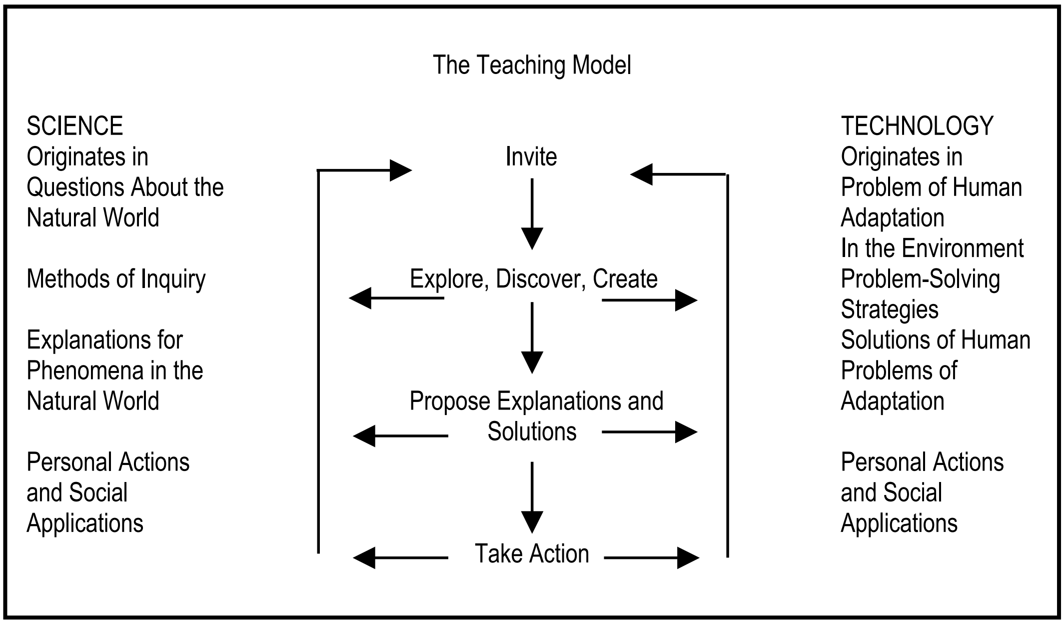
These concepts reflect the gradual recognition that learning is not simply a matter of acquiring knowledge and skill in one context (a workplace) and reapplying it in another (another workplace). Teaching and learning in the connective model is more a process and product of interaction within contexts and between contexts – and the successful mediation of these relationships is a pedagogic priority which includes recognizing that learning involves negotiation of learning as part of workplace experience.

*The underlying concepts of all the above mentioned models paved the way for the development of the ATL Model. The significance of* *experiential learning in activity-oriented learning contexts acts as the base for effective reflective learning. This pedagogy can be an effective measure for learning in out-of-school contexts.*

Accepting science learning in terms of '**knowledge construction'**, the ATL Model was developed based on the characteristics of the following models:

#### ***4.1.7.1 The constructivist-oriented model developed by Horsely et al (1990).***

The four stage model reflects the parallel, yet unique qualities of science and technology summarized in the following chart.




<u>**Figure 4.6**</u> **The constructivist-oriented model of Horsely et al (1990)**

The model shows the increasing interdependency of science, technology and society in relation to education as shown in Figure 4.7.

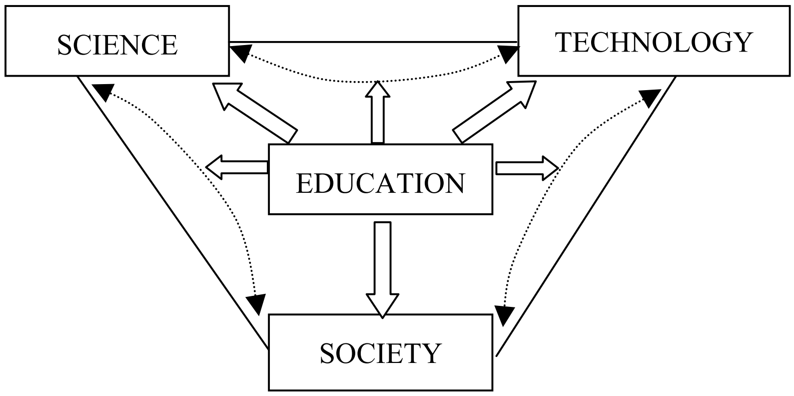



**Figure 4.7** **Role of education and interdependency of Science, Technology and Society**

The commercialization and industrialization of science and its integration with contemporary technology are also important for the values of science itself. This model provided the base for developing a model for learning in an apprenticeship mode in an industrial environment. It is expected to provide with pupils knowledge of scientific and technological applications in the productive sector.

#### *4.1.7.2 The 5E instructional model developed by Atkin and Karplus (1986)*

The 5E instructional model is based on a constructivist view. An assumption of this model is that using sequences of lessons designed to facilitate the process of learning will assist in students' construction of knowledge. Another is that concrete experiences and computer-assisted activities will assist in the process of construction of knowledge. The 5E instructional model is adjudged as one of the best that can be largely made use of in the preparation of an apprenticeship model of teaching and learning.

**The phases of the 5E model**

The model has five phases: engagement, exploration, explanation, elaboration, and evaluation. Each phase has a specific function and is intended to contribute to the learning process. The phases are described in terms of:

(1) assumptions about the mental activity of students,

(2) activities that students would be involved in, and

(3) strategies used by the teacher.

**Engagement**

In the first phase, the student is engaged in the learning task by mentally focusing on a problem, situation, or event. The activities of this phase make connections to past and future activities. The connections depend on the learning task and may be conceptual, procedural, or behavioral.

Asking a question, defining a problem, and showing a discrepant event are all ways to engage students and focus them on the instructional task. The teacher's role is to present the situation and identify the instructional task. The teacher also sets the rules and procedures for establishing the task. Figure 4.8. summarizes the engagement phase.

**Orientation**

This phase of the teaching model initiates the instructional task. The activity should (1) make connections between past and present learning experiences, and (2) anticipate activates and organize students' thinking toward the learning outcomes of current activities.

**Students**

Establish an interest in, and develop an approach to the instructional task.

**Teachers**

Identify the instructional task.

**Activities**

May vary, but should be interesting, motivational, and meaningful to students.

**Learning**

Initiated by, exposure to, and experience with concepts, processes, and skills.

**<u>Figure 4.8</u> Engagement phase of 5E model**

Successful engagement results in students being puzzled and actively motivated in the learning activity. Here activity is used in the constructivist and behavioral sense that students are mentally active. If the external events are combined with the basic needs and interests of the students, instruction contributes to successful learning.

**Exploration**

**Orientation**

This phase of the teaching model provides the students with a common base of experience within which current concepts, processes, and skills may be identified and developed.

**Students**

Complete activities directed toward learning outcomes.

**Teachers**

Facilitate and monitor interaction between students and instructional situations, materials, and/or courseware.

**Activities**

Provide mental and physical experiences relative to the learning outcomes. These activities provide and initial context for students' explanations as they have unanswered questions based on the exploration.

**Learning**

Directed by objects, events, or situations.

**Figure 4.9 Exploration phase of 5 E Model**

The aim of exploration activities is to establish experiences that a teacher can use later to formally introduce a concept, process, or skill. During the activity, the students have time in which they explore objects, events, or situations. Some of the key words used to describe the type of activities used in this phase are concrete and hands-on. Courseware can be used in the phase, but it should be carefully designed to assist the initial process of conceptual reconstruction.

As a result of their mental and physical involvement in the exploration activity, students establish relationships, observe patterns, identify variables, and question events.

The teacher's role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and allows students the time and opportunity to investigate objects, materials, and situations based on each students, materials, and situations based on each student's own concepts about phenomena, If called upon, the teacher may coach or guide students. Use of concrete materials and experience is essential.

**Explanation**

The explanation phase is teacher (or technology) directed. Teachers have a variety of techniques and strategies at their disposal.

. Educators commonly use oral explanations, but there are other strategies, such as video, film; and educational courseware. This phase continues the process of cognitive construction and provides words for explanations. In the end, students should be able to explain exploratory experiences using common terms. Students will not immediately express and apply the explanations learning takes time. Students need time and experience to establish and expand concepts, processes, and skills. In this phase, the teacher directs student attention to specific aspects of the engagement and exploration experiences.

**Orientation**

This phase of the teaching model focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviours. This phase also provides specific opportunities for teachers to introduce concepts or skills.

**Students**

Describe their understanding, use their skills, express their attitudes

**Teachers**

Direct student learning by clarifying misconceptions, providing vocabulary for concepts, giving examples, of skills, modifying behaviours, and suggesting further learning experiences.

**Activities**

Provide opportunities to identify student knowledge, skills and values, and to introduce language and / or behaviors related to learning outcomes.

**Learning**

Directed by teacher and instructional courseware

**Figure 4.10** **Explanation phase of 5 E Model**

First, students are asked to give their explanations. Second, the teacher introduces scientific or technological explanations in a direct and informal manner. Explanations are ways of ordering the exploratory experiences. The teacher should base the initial part of this phase on students' explanations and clearly connect the explanations to experiences in the engagement and exploration phases of the instructional model.

The key to this phase is to present concepts, processes, or skills in a simple, clear, and direct manner, and move on to the next phase. The explanation phase can be relatively short because the next phase allows time for restructuring and extends this formal introduction to concepts, processes, and skills.

**Elaboration**

Once students have an explanation of their learning tasks, it is important to involve students in further experiences that extend or elaborate the concepts, processes, or skills. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaboration activities provide further time and experiences that contribute to learning. During the elaboration phase, students engage in discussions and information-seeking activities. The groups' goal is to identify and execute a small number of promising approaches to the task.

During the group discussion, students present and defend their approaches to the instructional task. This discussion results in better definition and gathering of information that is necessary for successful completion of the task. The teaching cycle is not closed to information from the outside. Students get information from each other, the teacher, printed materials, experts, electronic databases, and experiments they conduct. This is called the information base. As a result of participation in the group's discussion, individual students are able to elaborate upon the conception of the tasks, information bases, and possible strategies for its completion.

A summary of the elaboration phase of the teaching model is presented in Figure 4.11.

**Orientation**

This phase of the teaching model challenges and extends students' conceptual understanding and skills. Through new experiences students develop deeper and broader understanding, more information, and adequate skills.

**Students**

Present and defend their explanations and identify and complete several experiences related to the learning task.

**Teachers**

Provide an occasion for students to cooperate on activities, discuss their current understanding, and demonstrate their skills.

**Activities**

Provide experiences through challenges, repetition, new activities, practice, and time

**Learning**

Encouraged through challenges, repetition, new experiences, practices, and time.

**Figure 4.11** **Elaboration phase of 5 E Model**

Interactions within student groups are an application of Vygotsky's psychology to the teaching model. Group discussions and cooperative learning situations provide opportunities for students to express their understanding of the subject and receive feed back from others who are close to their own level of understanding. The phase is also an opportunity to involve students in new situations and problems that require the application of identical or similar explanations.

**Evaluation**

At some point, students should receive feedback on the adequacy of their explorations. Informal assessment can occur from the beginning of the teaching sequence. The teacher can complete a formal assessment after the elaboration phase. Figure 4.12. summarizes the evaluation phase.

**Orientation**

This phase of the teaching model encourages students to assess their understandings and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

**Students**

Examine the adequacy of their explanations, behaviors, and attitudes in new situations.

**Teachers**

Use a variety of formal and informal procedures for assessing student understanding.

**Activities**

Evaluate the concepts, attitudes, and skills of the students.

**Learning**

Repeat different phases of the teaching model to improve conceptual understanding and/or skills.

**Figure 4.12** **Evaluation Phase of 5 E Model**

As a practical educational matter, teachers must assess educational outcomes. This is the phase in which teachers administer tests or performance activities to determine each student's understanding. This is also the important opportunity for students to use the skills they have acquired and evaluate their own understanding.

Thus the 5E instructional model is aligned with many processes involved in scientific inquiry. It provides valuable guidelines for designing learning experiences in constructive and scientific ways. The learning sequences in ATL Model were developed based on the concepts and processes explained in this model.

#### *4.1.7.3 Cognitive Apprenticeship Model*

Recent developments in the understanding of cognition and meta-cognition have influenced the conceptualization of pedagogy. In part, this reflects the increased awareness of the need to think of learners as active constructors of meaning. Bruner (1996) puts forward a model which reflects recent research into cognition – seeing children as thinkers, constructing a model of the world to help them construe their own experience. The model considers what children think and how they arrive at what they believe and focuses on sharing knowledge within the discourse of a particular community. It links to another understanding of cognition, that what is learned relates strongly to the situation in which it is learned.

"Situations might be said to co-produce knowledge through activity", (Brown et al, 1989). This view has led to an approach – sometimes called 'cognitive apprenticeship' – which makes deliberate use of the social context in which knowledge can become an authentic tool. It sees learning as being embedded in the activity of particular environments.

The cognitive apprenticeship model developed by Collins et al (1992) is based on traditional adult craft apprenticeships adapted to the teaching if reading, writing and arithmetic. The concept of apprenticeship is seen in both adult and child learning activities through the use of techniques such as coaching, modeling and observation. Unlike adult apprenticeships for vocational training, cognitive apprenticeship combines strategy training with skills such as social interaction, observation, practice and reflection. The model requires that teachers facilitate learning through modeling and supporting students' learning, not through providing answers.

This approach has four independent elements: content, methods, sequence and sociology.

Content ➔ knowledge from the specific content area (domain knowledge)

Understanding from knowledge of previous experience (heuristics)

monitoring and organizational skills (control or metacognitive strategies) and

techniques that have been used previously in learnig new tasks ( learning strategies).

Methods ➔ guided practices (e.g.: modelling and coaching)

Exploration (e. g.: verbalizing the problem solving process, reflection)

Sequence ➔ three sequencing approaches – increasing capacity, diversity and developing global strategies before specific skills, allow students of differing ability to participate in a programme using the same set of experiences but with different individual outcomes.

Sociology ➔beliefs, values, culture and social settings, in the real world, that form the context in which learning occurs.

Thus the cognitive apprenticeship model involves sociology-based learning, developing motivation through real rather than contrived problem solving situations using co-operative learning and developing a language of learning.

The 'Cognitive apprenticeship model' of Jolliffe et al. (2001) is based on various conditions of learning: like a meaningful context, ongoing activities providing immediate feedback, imitative learning to establish connections between learning experiences, objective-oriented learning which functionally viable etc. The model discards the dichotomy between education and training and helps the learner to get proficiency. The management of the model includes components like goal setting, strategic planning, monitoring, evaluation and revision.

The learning strategies cover concepts of knowledge of how to learn, like exploring new fields, acquiring new knowledge and reworking on the already gained knowledge. If the traditional apprenticeship is organized for training opportunities in real situation, the driving force is the progressive mastering of tasks with an immediate outcome of the work being done. Learning involves the skill and efficiency to do something and not merely to talk about it.

The above mentioned models signify the incorporation of apprenticeship in the teaching/learning process, as a learning strategy rather than a training technique. This view acted as a motivating force to develop the ATL Model

#### *4.1.7.4 The Learning Cycle*

Another instructional model is the learning cycle. The learning cycle originated in the 1960s with the work of Robert Karplus and his colleagues during the development of the of the Science Curriculum Improvement Study (SCIS), Originally, the learning cycle was based on the theoretical insights of Piaget, but it is consistent with other theories of learning, such as those developed by Ausubel.

This cycle is a three-step instructional sequence that includes exploration, invention, and discovery that were first used in the SCIS program. Later, these terms were modified to

- Concept exploration
- Concept introduction, and
- Concept application.

During exploration, students learn through their involvement and actions. New materials, ideas and relationship are introduced with minimal teacher guidance. The goal is to allow students to apply previous knowledge, develop interests, and initiate and maintain a curiosity toward the materials. The material should be carefully structured so involvement with them cannot help but engage concepts and idea fundamental to the lesson's objective. During the exploration, teachers can also assess students' understanding and background related to the lesson's objectives.

In the next phase, Introduction, various teaching strategies can be used to introduce the concept. For example, a demonstration, film textbook, or lecture can be used. This phase should relate directly to the initial Exploration and clarify concepts central to the lesson. Although the Exploration was minimally teacher-directed, this phase tends to be more teacher-guided.

In the next phase, Application, students apply the newly learned concepts to other examples. The teaching goal is to have students generalize or transfer ideas to other examples used as illustrations of the central concept.

**Steps for designing lessons - Applying the learning cycle**

**Concept Exploration**

1. Identify interesting objects, events, or situations that students can observe, student experiences can occur in the classroom, laboratory, or field. Many instructional methods can be used to explore a concept.
2. Allow students time to explore the objects, events, or situations. During this experience, students may establish relationships, observe patterns, identify variables, and question events or experiences that motivate them to study what they have observed.
3. The primary aim of the exploration is to have students think about concepts associated with the lessons.

**Concept Introduction**

4. The teacher directs student attention to specific aspects of the exploration experience. Initially, the lesson should be clearly based on student explorations. In this phase, the key is to present the concepts in a simple clear and direct manner.

**Concept Application**

5. Identify different activities in which students extend the concepts in new and different situations. Several different activities will facilitate generalization of the concept by the students. Encourage students to identify patterns, discover relationships among variables, and reason through new problems.

Renner (1985) and his colleagues examined the effectiveness of altering the sequence of the learning cycle. They found that the normal sequence (described above) is the optimum sequence for achievement of content knowledge.

Lawson (1988) proposes three types of learning cycles: descriptive, empirical-inductive, and hypothetical deductive. Although the sequence is similar to that described above, the difference among the types of learning cycles is the degree to which students gather data in a descriptive manner, or in a manner that empirically tests alternative explanations.

In descriptive learning cycles, students observe natural phenomena, identify patterns, and seek similar patterns elsewhere. Little or no disequilibrium occurs in descriptive learning cycles.

Empirical-inductive learning cycles require students to explain phenomena, thus expressing any misconceptions and providing opportunities for dialogue and debate.

Hypothetical-deductive learning cycles require students to make explicit statements of alternative explanations of phenomena. Higher order reasoning patterns are required to test alternative explanations.

**Learning cycle developed by Walker (1988)**

This model for teaching emerged after years of research on the factors that help students learn and remember as well as the factors that prevent understanding and retention. It is called the learning cycle because the emphasis is on student learning – where it belongs.

Walker (1998) calls this type of quality learning 'strategic learning' because it follows a strategy that is built on meaningful learning. There is an emphasis on depth of learning – rather than just covering a great deal of material. Students are given sufficient time and resources to make the learning a part of long-term memory. Connections are made to the real world and most students can be taught anything as long as it is relevant to their world. The classroom emphasizes collaboration and dialogue. Assessment is a natural progression of the lesson. The environment in the classroom is collaborative and supportive. The learning cycle is diagrammatically represented as given in Figure 4.13.

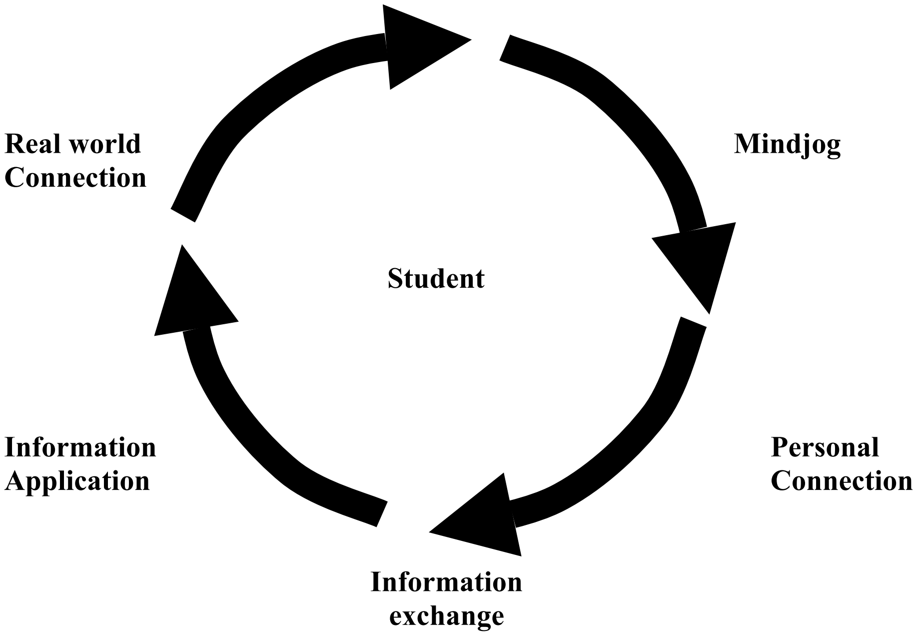



**Figure 4.13** **Learning Cycle developed by Walker, (1998).**

## Learning Cycle - Constructing Knowledge

### *Part 1- Mindjog*

Mindjogs are activities that emphasize higher level thinking and creativity. Its purpose is to jog the mind to prepare for the learning. Mindjogs are always high level, interesting, and meaningful. Gardner

(1983) calls this the time of “awakening”. Mindjogs awaken the brain and prepare it for the mental workout.

***Part 2 - Personal connection***

Too often, young people do not recognize connections between events in their everyday lives and what schools teach them. They cannot see the links between what they already know and what they are being taught. When new information is given to use without any connection in the brain, there is chaos until a connection is made.

Thus before the lesson, the teachers use direct questioning to determine what students know about the content from prior instruction and personal experiences. The teacher may guide students to categorize the information they have generated. This is an opportunity to correct misconceptions students may have about the information to be studied. This technique may also be used to build interest in the topic.

***Part 3 - Information Exchange***

“In brain-based learning, educators see learners as active participants in the learning process. The teacher is not the deliver of knowledge, but the facilitator and intelligent guide who engages student interest in learning” (Caine & Caine, 1997, p. 87)

Information exchange is the teaching of the lesson with a minimum of lecture. Information exchange emphasizes a curriculum of substance in which

- Students are required to do serious work.
- Instructional strategies that engage students and make them part of the learning process are the rule, not the exception.
- There is a climate supportive of teaching and learning.
- Technology is a part of the teaching and learning and goes far beyond drill and practice.
- Learning is brain based.
- Multiple resources are used.
- Lecture is limited to 15 minutes.
- Collaboration is encouraged

**Learning cycle - Demonstrating Understanding**

***Part 4 - Information Application***

Students are given the opportunity to demonstrate understanding of the learning by using the information they have learned in some way. Students who learn best by tactile or visual means need the opportunity to use graphic or concrete models to help solidify the information – concrete models help to put ideas in concrete for the student.

**Learning cycle - Reflecting on the Learning**

***Part 5 - Real-World Connection.***

A fundamental goal of education is the ability to deal with various and competing ways of understanding the universe. Knowing how to spell is not enough. Whenever students are being helped to see major concepts, big ideas, principles, and generalizations and not merely engaged in the pursuit of isolated facts, better teaching is going on (Haberman, 1997; p. 3)

This part of the learning includes these two aspects:

1. Showing students how they are going to use the information in the real world.
2. Helping students reflect on the learning. This is a time of metacognition in which students evaluate the learning and its meaning to their world. Glasser (1994, p. 1) said, "Our curriculum is worthless if we cannot convince students they are learning useful life skills".

The model provides the way for helping students to process and construct knowledge through experiences and reflection on them. The development of ATL Model relied on this idea to a very great extent.

***4.1.7.5 The 4MAT System developed by McCarthy (1987).***

The 4MAT System is based on the premise that individuals perceive and process experiences and information in different ways. The system moves through a four-phase learning cycle in sequence.

**Concrete Experience**
(Sensing / Feeling)

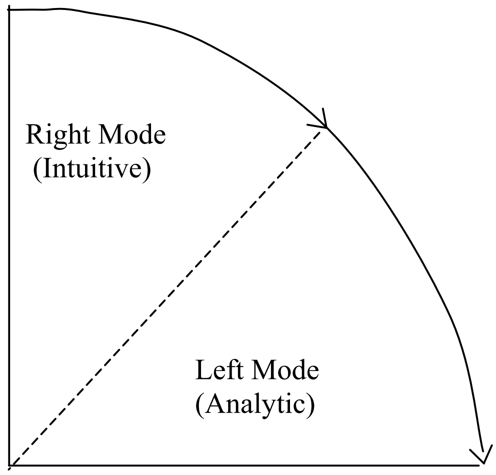



**Fig. 4.14. First phase of the 4MAT system, Refective observation**

**Reflective Observation**
(Watching/ Reflecting)

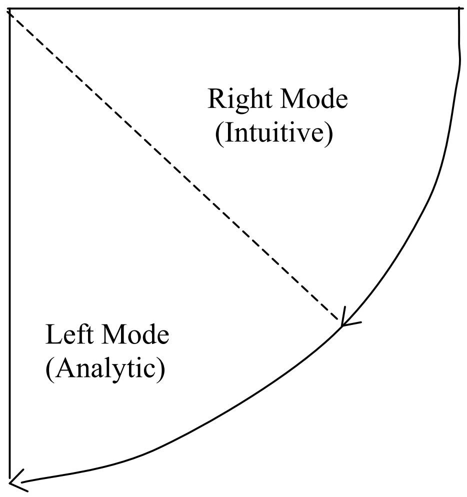
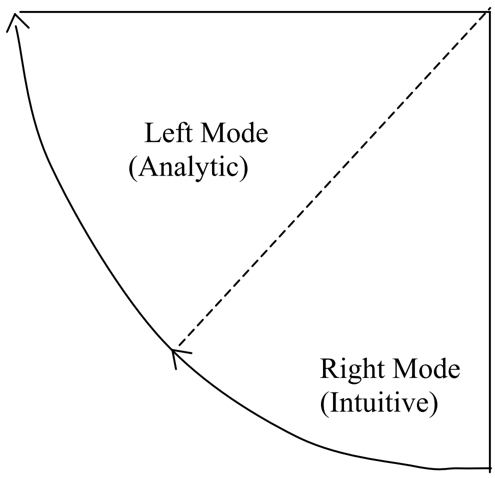



**Fig. 4.15. Second phase of the 4MAT system, Abstract conceptualization**

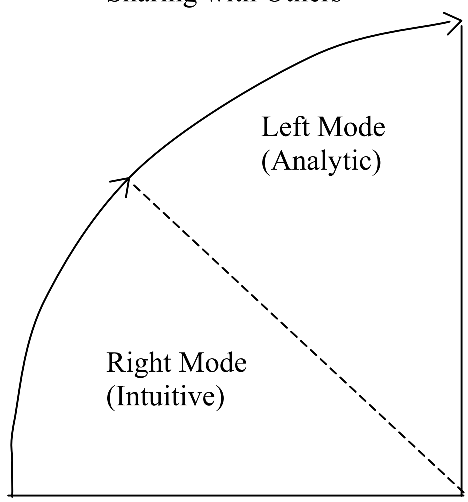
**Active Experimentation**
(Reinforcement & Manipulation




**Abstract Conceptualization**
(Thinking / Developing Concepts)

**Fig. 4.16.**
**Third phase of the 4MAT system, Active experimentation**

**Concrete Experience**
(Usefulness & Application)
Sharing with Others




**Active Experimentation**
(Reinforcement and Manipulatino)

**Fig. 4.17.**
**Final phase of 4MAT system, Concrete experience**

The first phase begins with a concrete experience and allows students time to discover the meaning that experience has for them i.e. the learner moves from concrete experience to reflective observation. This approach creates a reason for learning.

The second phase is the formulation of the concept. The student moves from reflective observation to abstract conceptualization. Teachers teach in the traditional sense. This approach gives the big idea.

In the third phase, students move from abstract conceptualization to active experimentation. This is the hands-on approach to science. Students are concerned with finding out how things work. The teacher's role is to provide the materials and opportunity.

The final phase is the progression from active experimentation to concrete experience. The students combine knowledge from personal experience and experimentation.

Thus there are four identifiable learning styles and each is an equally valid way of learning.

### *4.1.7.6 A contextual model of learning in informal contexts*

Falk and Dierking (2000) have devised a model that helps us understand learning in situations that are relatively 'informal' when compared with normal schooling. The basic elements of the model shown as given in Figure 4.18.

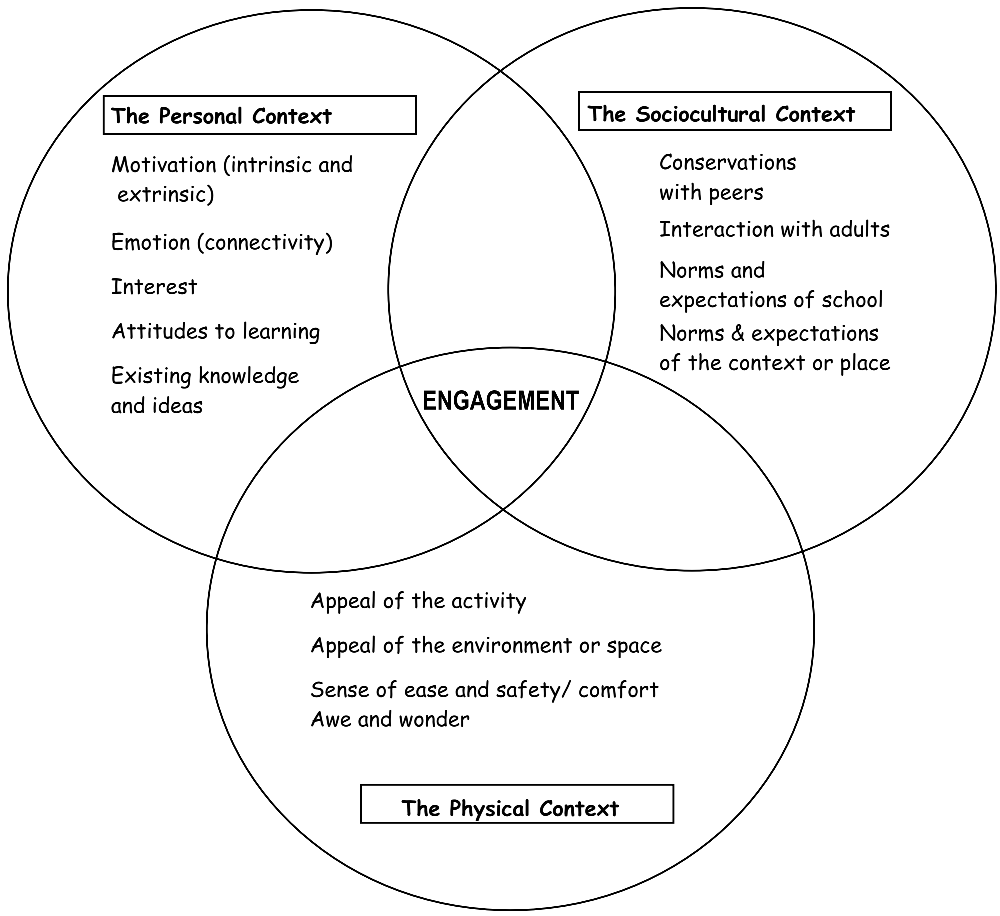



**Figure 4.18. A contextual model of learning by Falk and Dierking (2000).**

By 'informal' they mean that pupils have some element of choice in what they do, the directions of learning they follow or the amount of time and effort spent. The model is very useful in helping understand what learners experience and how experiences can be enhanced to get the most from these contexts.

The model is based on three overlapping contexts, each effecting the engagement of the learner and ultimately the quality and quantity of what the learner gains from their experiences.

In the personal context, pupils' learning flows from a set of emotional and motivational cues. In this way pupils operate in the affective domain discussed above and this often sets up the desire to want to find our new things or go deeper into learning about something already encountered. The impact can be surprisingly long-lasting and even life-enhancing.

The physical context has a lot to do with providing these emotional and motivational cues. For many pupils science comes alive when they experience phenomena, specimens and artifacts in natural settings. At times, though, such learning environments can spark initially negative reactions. For example, pupils initial views of factories and manufacturing sites are often stereotypically of dark and threatening places pouring out pollution. Teaching science using industrial contexts and visits, however, is capable of changing these perceptions.

The ways in which we act in and react to different learning situations is a product of our culture and society impose a set of social norms which set expectations and give rise to rules about how we behave in different situations. These are key aspects of what Falk and Dierking call the sociocultural context. School groups working outside the classroom act as a 'community of learners'. Each community of learners has its own characteristic behavious and the actions of its members depend on previously established cultural and educational norms.

In school, teachers know what these norms are and with experience can predict pupils' likely reactions and behaviour. In out-of-school and informal contexts the norms of school begin to break down and may even conflict with the approaches to learning and expectations that the informal situation provides. Teachers can see this as a problem or as an opportunity. It only becomes a problem if we do not realize that new norms and sociocultural expectations apply in these circumstances and when we fail to make allowances for them.

**Conclusion**

New opportunities for learning science abound. Working in such contexts allows pupils to express themselves in ways that school does not. All the above mentioned theories and models focus on processing information as the best way for learning by students, than merely acquiring knowledge. These suggest that means for this is through personal and purposeful experiences in real and natural environments. Reflection finds a major role in making meaning out of experience. Thus the theories and models reviewed helped a lot in the development of the ATL Model.

## 4.2 Pre-preparation of the ATL Model

The pre-preparation of the ATL Model involved the following steps:-

**4.2.1. Identification of Chemistry education potential of industries in Kerala.**

**4.2.2. Field studies and reports of selected industries - By the investigator and the students.**

**4.2.3. Outcomes of Field studies.**

The details are presented in the following sections.

### 4.2.1 Identification of Chemistry education potential of industries in Kerala

The potential of an industrial environment as an outdoor learning centre was mainly determined by the content it emphasizes and the kinds of activities which enhance higher levels of learning and meta cognition. To identify the chemistry education potential of the different sectors of industries in Kerala, the topics in the HSS curriculum directly or indirectly related to the chemical processes and principles involved in industries are identified based on the structure analysis of industries. This involved the following steps:

#### *4.2.1.1 Analysis of different sectors of industries in Kerala*

The categorization of chemical/chemistry applied industries based on the products manufactured was taken as a preliminary step towards the identification of the chemistry education potential of industries. The different categories/sectors of industries selected were presented as follows.

***Table 4.2***

***Product-wise Classification of industries***

| SECTOR | INDUSTRIES |
|---|---|
| 1 | Cement |
| 2 | Fertilizers & Chemicals |
| 3 | Petrochemicals |
| 4 | Pharmaceuticals |
| 5 | Paper& Pulp |
| 6 | Aluminium |
| 7 | Refinery |
| 8 | Sugar & Solvent |
| 9 | Zinc |
| 10 | Pesticides/insecticides. |

| | |
|---|---|
| 11 | Clay |
| 12 | Rubber |
| 13 | Carbon |
| 14 | Dye & Dye intermediate |
| 15 | Textile |
| 16 | Minerals & Metals |
| 17 | Plastic |
| 18 | Soaps & Detergents |
| 19 | Fibers |
| 20 | Thermal power plant |

The investigator collected relevant data regarding the products, production units, processes involved in production etc. of the above mentioned sectors of industries from various sources like Industries Department, SIDCs and PCB. She visited the factories and discussions with the officials and staff of the factories helped a lot in identifying the extent of application of chemical principles and allied aspects in the industrial sector. It was found that those industrial environments could be effectively used for learning so many topics in the school curriculum. The details are evident in the correlation with contents in the HSS curriculum as presented in Table 4.3.

#### 4.2.1.2 Analysis of the contents of the present HSS Chemistry textbook

As a prerequisite for identifying the chemistry education potential of industries in Kerala, the chemistry textbook at the HS level (both XI and XII) was analyzed in order to locate the industry-related topics. The major areas in the HSS textbook selected were given below:

**Table 4.3**

**Content areas in the HSS chemistry text book**

| No | Topics | Level | |
|---|---|---|---|
| | | XI | XII |
| 1 | Separation of mixtures – Processes used for separation – filtration, distillation, fractional distillation, gravity separation, magnetic separation etc | ✓ | |
| 2 | Chemical combinations and decompositions | ✓ | |
| 3 | Crystals and properties – Ionic, molecular and co-valent | ✓ | ✓ |
| 4 | Energy producing cells | ✓ | ✓ |
| 5 | Liquid state – properties – diffusion, evaporation, vapour pressure, boiling point, surface tension, viscosity etc. – Liquid crystals | ✓ | ✓ |
| 6 | Alkali metals & Alkaline earth metals and their compounds | ✓ | ✓ |
| 7 | Transition elements – properties and uses – alloy formation | ✓ | ✓ |
| 8 | Transition elements – coloured ions and compounds | ✓ | ✓ |
| 9 | Inner transition elements – compounds and applications | ✓ | ✓ |
| 10 | Sources of energy – coal, petroleum, natural gas | ✓ | |
| 11 | Conversion of chemical energy into other forms of energy | ✓ | |
| 12 | Pollution associated with consumption of fuels | ✓ | |
| 13 | Catalysts – catalysis - enzymes | ✓ | ✓ |
| 14 | Electrochemistry - Electrolytes – Electrolysis - Electrochemical series | ✓ | ✓ |
| 15 | Solutions – properties – Osmosis - Buffer solutions | ✓ | ✓ |
| 16 | Hard and soft water | ✓ | |
| 17 | Resins – for recycling industrial waste water | ✓ | |

| No | Topics | | Level | |
|---|---|---|---|---|
| | | | XI | XII |
| 18 | Nitrogen and its compounds – properties and uses | | ✓ | ✓ |
| 19 | Ammonia – preparation and properties | | ✓ | |
| 20 | Properties and uses of Nitric acid | | ✓ | |
| 21 | Borax – uses in candle industry and for the manufacture of enamels and glazes for earthen pots | | ✓ | |
| 22 | Silicon & its compounds – Silicones – preparation, properties and uses –as insulators and resins | | ✓ | ✓ |
| 23 | Silicates – preparation and properties – glass | | ✓ | ✓ |
| 24 | Phosphorous – compounds – properties | | ✓ | ✓ |
| 25 | Chemical fertilizers – classification and properties | | ✓ | |
| 26 | Sulphur – compounds and uses – as fungicide and insecticide in agriculture – used in sulpha drugs | | ✓ | |
| 27 | Manufacture of Sulphuric acid – properties | | ✓ | |
| 28 | Fluorine compounds – manufacture of $UF_6$ - for nuclear power generation | | ✓ | |
| 29 | Chlorine – uses – production of organic compounds like PVC, chlorinated hydrocarbons, pharmaceuticals, pesticides etc., used for bleaching paper pulp and textiles, used for the preparation of HCl and bleaching powder | | ✓ | |
| 30 | Extraction of metals | | ✓ | |
| 31 | Metallurgy – Processes | | ✓ | |
| | i) | crushing and pulverization of the ore | ✓ | |
| | ii) | Concentration or benefaction of the ore | ✓ | |
| | a) | levigation or washing | ✓ | |
| | b) | froth floatation process | ✓ | |
| | c) | leaching | | |
| | iii) | Extraction of the metal from concentrated ore | ✓ | |
| | a) | calcination | ✓ | |
| | b) | roasting – smelting/reduction with Al, Mg, Hydrogen or water gas | ✓ | |

| No | Topics | | Level | |
|---|---|---|---|---|
| | | | XI | XII |
| | iv) | Purification and refining of crude oil | | |
| | a) | liquation | ✓ | |
| | b) | cupellation | ✓ | |
| | c) | poling | ✓ | |
| | d) | electrolytic refining | ✓ | |
| | e) | zone refining | ✓ | |
| | v) | Mineral wealth of India | ✓ | |
| 32 | Corrosion | | ✓ | |
| 33 | Chemistry of lighter metals – compounds, extraction of metals etc | | ✓ | ✓ |
| 34 | Calcium and its compounds | | ✓ | |
| 35 | Plaster of Paris and Gypsum | | ✓ | |
| 36 | Aluminium and its compounds | | ✓ | |
| 37 | Extraction of Aluminium | | ✓ | |
| 38 | Alums - preparation and properties | | ✓ | |
| 39 | Cement – preparation and properties | | ✓ | |
| 40 | Iron – Extraction – Compounds | | ✓ | |
| 41 | Preparation of steel | | ✓ | |
| 42 | Zinc – extraction and compounds | | ✓ | |
| 43 | Organic chemistry | | ✓ | |
| 44 | Carbon – forms - Graphite - structure and properties – Compounds of Carbon – oxides of Carbon | | ✓ | ✓ |
| 45 | Industrial resources of hydrocarbons | | ✓ | |
| 46 | Coal and petroleum | | ✓ | ✓ |
| 47 | Oil refining | | ✓ | |

| No | Topics | Level | |
|---|---|---|---|
| | | XI | XII |
| 48 | Processes in Petroleum industry | ✓ | |
| 49 | Purification of organic compounds | ✓ | |
| 50 | Quantitative analysis – Estimation of elements | ✓ | |
| 51 | Proteins – structure and properties | ✓ | ✓ |
| 52 | Properties of solids | ✓ | |
| 53 | Types of reactions | ✓ | ✓ |
| 54 | Properties and reactions of Halo alkanes and Halo arenes | ✓ | |
| 56 | Manufacture of alcohols and phenols – properties and reactions | ✓ | |
| 55 | Glycerine - properties and reactions | ✓ | |
| 56 | Preparation and properties of aldehydes, ketones and ethers | ✓ | |
| 57 | Carboxylic acids and its derivatives – preparation and properties | ✓ | |
| 58 | Nitro alkanes – uses in plastic industry, for the production of explosives and detergents | ✓ | |
| 59 | Amines – properties and uses – used for the manufacture of dyes, drugs and indicators – synthesis of several organic compounds – amine salts of carboxylic acids used as herbicides | ✓ | |
| 60 | Nuclear chemistry – radioactivity – natural and artificial – application of radioisotopes | ✓ | |
| 61 | Nuclear fission and nuclear fusion – nuclear reactors | ✓ | |
| 62 | Polymers – natural, synthetic and commercially important – examples | ✓ | |
| 63 | Fibers – natural and condensation polymers | ✓ | |
| 64 | Synthetic rubbers | ✓ | |
| 65 | Colloids – Properties – coagulation - emulsifiers | ✓ | |
| 66 | Dyes – classification | ✓ | |
| 67 | Vitamins – Lipids – waxes - preparation | ✓ | |
| 68 | Chemicals in medicine – pharmaceuticals | ✓ | |
| 69 | Chemistry of rocket propellants | ✓ | |

#### 4.2.1.3 Identification of Chemistry education potential of industries in Kerala

The industry-related topics identified were correlated to the data collected from the structure analysis of industries. The topics that can be learned within a particular industrial sector is grouped which gives the education potential of that sector of industries. Thus the chemistry education potential of twenty sectors of industries are analyzed, the details of which are given in Table 4.4.

**Table 4.4**

**Education potential of various industrial sectors**

| Sl. No | Industrial Sector | Education potential |
|---|---|---|
| 1 | Cement | Cement – preparation and properties, Plaster of Paris and Gypsum, Calcium and its compounds, silicates – preparation and properties, alkali and alkaline earth metals and their compounds, chemical combinations and decompositions separation of mixtures, pollution associated with industrial processes, catalysts and catalysis, phosphorous – compounds and properties, quantitative analysis, types of reactions. |
| 2 | Fertilizers & Chemicals | Chemical fertilizers – classification and properties, phosphorous – compounds and properties, environmental pollution, nitrogen and its compounds – properties, ammonia – preparation and properties, properties and uses of nitric acid, Sulphur – compounds and uses, Sulphuric acid – properties, Chlorine – uses, alums – preparation and properties, preparation and properties of aldehydes, ketones and ethers, nitro alkanes – uses, amines – properties |

| Sl. No | Industrial Sector | Education potential |
|---|---|---|
| 3 | Petrochemicals | Coal and petroleum, processes in petroleum industry, industrial resources of hydrocarbons, purification of organic compounds, liquid state – properties, sources of energy – coal, petroleum, natural gas, pollution associated with consumption of fuels, manufacture of alcohols and phenols – properties , glycerine – properties and reactions, carboxylic acid and its derivatives, polymers and fibers, lipids – waxes – use of borax in candle industry |
| 4 | Pharmaceuticals | Chemicals in medicine – pharmaceuticals, vitamins – lipids – preparation, colloids – properties – emulsifiers, amines – use in the manufacture of drugs, proteins – structure and properties, alcohols and phenols – properties and reactions, aldehydes – ketones – ethers – reactions, carboxylic acid and derivatives – properties, glycerine – reactions, halo alkanes and halo arenes – properties, separation of mixtures, properties and uses of nitric acid, uses of chlorine for producing pharmaceuticals |
| 5 | Paper & pulp | Preparation of paper from wood, use of chlorine in bleaching paper pulp, industrial resources of hydrocarbons, natural and condensation polymers, colloids – properties. |
| 6 | Aluminium | Aluminium and its compounds, extraction of aluminium, extraction of metals – roasting – smelting/reduction with aluminium, electro chemistry – electrolysis, alums – preparation and properties, hard and soft water. |
| 7 | Refinery | Oil refining, coal and petroleum, processes in petroleum industry, organic chemistry, purification of organic compounds, purification and refining of crude oil – liquation, cupellation poling, electrolytic refining, zone refining etc. |

| Sl. No | Industrial Sector | Education potential |
|---|---|---|
| 8 | Sugar & Solvents | Alcohols and phenols – manufacture – properties – reactions, solutions – properties, liquid state, separation of mixtures, purification of organic compounds, glycerol – properties. |
| 9 | Zinc | Zinc – extraction and compounds, energy producing cells, electrolysis, Transition elements – properties and uses – alloy formation |
| 10 | Pesticides/insecticides | Sulphur – compounds and uses – as fungicide and insecticide in agriculture, uses of chlorine – production of bleaching powder and pesticides, environmental pollution, halo alkanes and halo arenes, aldehydes, ketones – properties, amine salts of carboxylic acids – properties and uses |
| 11 | Clay | Composition and uses of clay, silicates – properties, preparation of cement, Aluminium and its compounds, Calcium and its compounds |
| 12 | Rubber | Natural and synthetic rubber, polymers – natural, synthetic and commercially important – examples, fibers – natural and condensation polymers, colloids – properties – coagulation – emulsifiers |
| 13 | Carbon | Carbon – forms – Graphite – structure and properties – uses of carbon – compounds of carbon – oxides of carbon, industrial resources of hydrocarbons, crystals and properties |
| 14 | Dye & dye intermediate | Dyes – classification, use of amines for the manufacture of dyes and indicators, uses of dyes – estimation of elements, properties of aldehydes, ketones, ethers |
| 15 | Textile | Fibers – natural and condensation polymers, polymers – natural, synthetic and commercially important, uses of dyes |

| Sl. No | Industrial Sector | Education potential |
|---|---|---|
| 16 | Minerals & Metals | Metallurgy – processes, extraction of metals, mineral wealth of India, lighter metals – compounds, Iron – extraction – compounds, electrolysis – electrochemical series, preparation of steel, corrosion, properties of solids, Silicon and its compounds, catalysts – catalysis, crystals and properties, liquid crystals, alkali and alkaline earth metals and their compounds, properties of solids, types of reactions, transition and inner transition elements – compounds and applications |
| 17 | Plastic | Polymers – natural, synthetic and commercially important – examples, uses of nitro alkanes in plastic industry, silicones – preparation, properties and uses – as insulators and resins |
| 18 | Soaps and detergents | Carboxylic acids and its derivatives, glycerine – properties and reactions, use of nitro alkanes in the production of detergents, hard and soft water, liquid state – solutions |
| 19 | Fibers | Fibers – natural and condensation polymers, natural and synthetic polymers, resins for recycling industrial waste water, uses of silicones as insulators and resins, proteins – proteins – structure and properties. |
| 20 | Thermal power plant | Sources of energy – coal, petroleum, natural gas, conversion of chemical energy into other forms of energy, pollution, fluorine compounds – manufacture of UF6 for nuclear power generation, nuclear fission and nuclear fusion, transition and inner transition elements – properties, chemistry of rocket propellants |

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Thus the analysis revealed the opportunities for providing students with abundance of learning experiences for meaningful chemistry learning in an industrial environment.

**4.2.2 Field Studies and Reports of selected industries – By the investigator and the students**

***4.2.2.1 By the investigator***

For an in-depth analysis of the education potential of chemical/chemistry applied industries in Kerala, the investigator conducted field study of eight industries selected (Table 3.2.) and prepared reports. The data collected was consolidated and presented in Tables 4.5. and 4.6. Detailed report of the Kerala Salicylates and Chemicals Ltd. is presented in section 4.2.2.2 and that of the Travancore Cements, Kottayam is presented in section 4.4.1.1.

The observations made by the investigator in the learning environments helped in identifying concepts regarding the following:

1. The major products manufactured by these industries, their quantity, quality, industrial as well as practical uses for daily life.
2. The locally available resources used for production and their ready availability.

3. The geographic areas in Kerala where industry related chemicals are present and effectively utilized for production in the industrial areas.

4. The scientific processes used for manufacturing - These include

    a. purification of natural resources – washing, grinding, filtration, crystallization, electrolytic separation etc.

    b. mixing – the ratios in which different components/ chemicals are to be mixed for enhancing chemical reaction.

    c. catalytic reaction – Presence and role of catalysts in chemical processes

    d. estimation of composition of components

    e. extraction of products

    f. estimating quantity and quality of products

    g. formation of byproducts during manufacturing

    h. conditions / criteria that were to be observed for maximum yield of products.

    i. safety measures that were to be adopted while manufacturing

    j. other scientific processes that can give better yield of products

5. Major technological devices used in the field of industries depending upon the scientific process involved and the nature of products
6. Types of pollution caused by industries
7. The urgent need of the time – The local community, govt. authorities and the educational institutions must seek more opportunities for interaction with industries and render assistance and help in the proper existence and smooth functioning of the industries

The details of the structural analysis of the eight industries, conducted by the investigator, and their education potential are given in Table 4.5. and 4.6.

**Table 4.5**

**Structure Analysis of Industries**

| **Name of Industry** | **Travancore Titanium Products Ltd.** | **Kerala State Salicylates & Chemicals (KSSC) Limited** | **Kerala Minerals and Metals Ltd. (KMML)** | **Fertilizers and Chemicals, (FACT) Ltd.** | **Hindustan News Print Ltd. (HNL)** |
|---|---|---|---|---|---|
| **Category of industry** | Chemical | Pharmaceuticals | Minerals & Metals | Fertilizers | Paper & Pulp |
| **Locality and features of the site** | Kochuveli, a coastal area of Trivandrum district | Thumpa, , a coastal area of Trivandrum district | Chavara, a coastal area of Kollam district. | Udyogamandal, an industrial area of Eranakulam district | Mevelloor, a rural area of Kottayam district |
| **Divisions of production units** | Two - Titanium dioxide & Sulphuric acid. | Five – aspirin, salicylic acid, sodium salicylate, carbon dioxide and nitrogen | Two Titanium dioxide & Hydrochloric acid | Five – ammonia, sulphuric acid, phosphoric acid, ammonium phosphate, ammonium sulphate. | Two – news print plant and a cement plant |

| **Name of Industry** | **Travancore Titanium Products Ltd.** | **Kerala State Salicylates & Chemicals (KSSC) Limited** | **Kerala Minerals and Metals Ltd. (KMML)** | **Fertilizers and Chemicals, (FACT) Ltd.** | Hindustan News Print Ltd. (HNL) |
|---|---|---|---|---|---|
| **Raw materials used** | Ilmenite & Sulphur | Acetic acid, acetic anhydride, kerosene, pure air. | Hydrochloric acid, Lecotines/ Petroleum coke, Raw sand containing- Ilmenite, Rutile, Zircon, Leucoxene, Monazite, Sillimanite- | Naphtha, sulphur, rock phosphate, sulphur dioxide, carbon dioxide, gypsum, oleum. | Eucalyptus and other wood materials, bamboo and reed |
| **Major products/ byproducts** | Titanium dioxide ($TiO_2$), Potassium titanate & $TiO_2$ (special grade). | aspirin, salicylic acid, sodium salicylate, carbon dioxide and nitrogen | Titanium dioxide pigment, Titanium tetrachloride, beneficiated ilmenite | Ammonia, sulphuric acid, phosphoric acid, ammonium phosphate, ammonium sulphate, sulphur dioxide, carbon dioxide, gypsum, oleum. | Paper & paper pulp |

| Name of Industry | Travancore Titanium Products Ltd. | Kerala State Salicylates & Chemicals (KSSC) Limited | Kerala Minerals and Metals Ltd. (KMML) | Fertilizers and Chemicals, (FACT) Ltd. | Hindustan News Print Ltd. (HNL) |
|---|---|---|---|---|---|
| **Technical devices used** | Ball mills, digesters, rotary kiln, rotary vacuum filters | Furnace, compressors, reactors | Ilmenite benefication plant, acid regeneration plant | Acid regeneration plant | Chemical and chemi-mechanical pulp mill, de-inked pulp plant. |
| **Scientific processes involved** | Pulverization, reduction, decomposition, precipitation, combustion | Pressure carboxylation, dissolution, crystallization, hydrolysis. | Ilmenite Benificiation Process involving Roasting, Digestion, Calcination. Acid Regeneration Process involving Pre-concentration, Spray Roasting, HCl absorption, oxide slurry system. Chlorination process, Oxidation process, Pigment Finishing Process | Steam naphtha refining, contact process, crystallization, dehydration. | Solubilizingthe pulp, reduction, bleaching, |

| Name of Industry | Travancore Titanium Products Ltd. | Kerala State Salicylates & Chemicals (KSSC) Limited | Kerala Minerals and Metals Ltd. (KMML) | Fertilizers and Chemicals, (FACT) Ltd. | Hindustan News Print Ltd. (HNL) |
|---|---|---|---|---|---|
| **Products-uses and applicability** | As a pigment | In analgesic, antipyretic and anti-inflammatory applications. | As a pigment | As fertilizers, dehydrating agent. | As paper, card boards |
| **Type of pollution caused by the industry** | Red category – heavily polluting. | Orange category – moderately polluting | Red category – heavily polluting. | Orange category – moderately polluting | Green category – low polluting. |
| **Chemistry education potential at HSS level** | Preparation and properties of titanium dioxide, properties and uses of sulphuric acid, properties of potassium titanate, uses of titanium dioxide, | Chemicals in medicine – pharmaceuticals, vitamins – lipids – preparation, colloids – properties – emulsifiers, amines – use in the | Metallurgy – processes, extraction of metals, mineral wealth of India, lighter metals – compounds, Silicon and its compounds, catalysts –, | Chemical fertilizers – classification and properties, phosphorous – compounds and properties, environmental pollution, nitrogen and its compounds | Preparation of paper from wood, use of chlorine in bleaching paper pulp, industrial resources of hydrocarbons, natural and condensation |

| | | | | | |
|---|---|---|---|---|---|
| **Chemistry education potential at HSS level** | pollution caused by chemical waste. | manufacture of drugs, proteins – structure and properties, alcohols and phenols – properties and reactions, aldehydes – ketones – ethers – reactions, carboxylic acid and derivatives – properties, glycerine – reactions, halo alkanes and halo arenes – properties, separation of mixtures, properties and uses of nitric acid, uses of chlorine for producing pharmaceuticals. | transition and inner transition elements – compounds and alloy formation. coloured ions and compounds. applications. - | – properties, ammonia – preparation and properties, properties and uses of nitric acid, Sulphur – compounds and uses, Sulphuric acid – properties, Chlorine – uses, alums – preparation and properties, preparation and properties of aldehydes, ketones and ethers, nitro alkanes – uses, amines – properties. Nitrogen and its compounds – properties and uses. - Properties and uses of Nitric acid. | polymers, colloids – properties. |

***Table 4.6***

***Structure Analysis of Cement Industries***

| **Name of Industry** | **Malabar Cements** | **Cochin cements Ltd.** | **Travancore Cements Ltd.** |
|---|---|---|---|
| **Category of industry** | Cement (Portland) | Cement (Pazzolona) | Cement (White) |
| **Locality and features of the site** | Walayar, a rural area of Palakkad district | Mevelloor, a rural area of Kottayam district | Nattakom, an area near the back waters of Kottayam district. |
| **Divisions of production units** | Two - Portland cement & Portland pazzolona cement. | One - Portland pazzolona cement. | Three - White cement, grey cement, cement paint |
| **Raw materials used** | Limestone, laterite and gypsum | Cement clinker, fly ash, marine gypsum. | Lime shell, white clay, white sand & crystal gypsum. |
| **Major products/ byproducts** | Ordinary portland cement & Portland pazzolona cement. | Portland pazzolona cement | White cement, Grey cement, Cement paint. |

| Name of Industry | Malabar Cements | Cochin cements Ltd. | Travancore Cements Ltd. |
|---|---|---|---|
| **Technical devices used** | Raw mill, rotary kiln, ball mill & cement mill | Raw mill, rotary kiln, ball mill & cement mill | Raw mill, rotary kiln, ball mill & cement mill |
| **Scientific processes involved** | Dry process, reduction. | Dry process, reduction. | Wet process, reduction. |
| **Products-uses and applicability** | For construction purposes. | For construction purposes. | For construction purposes, as cement paint for fixing tiles. |
| **Type of pollution caused by the industry** | Red category – heavily polluting. | Red category – heavily polluting | Red category – heavily polluting |

| Name of Industry | Malabar Cements | Cochin cements Ltd. | Travancore Cements Ltd. |
|---|---|---|---|
| **Chemistry education potential at HSS level** | Cement – preparation and properties, Plaster of Paris and Gypsum, Calcium and its compounds, silicates – preparation and properties, alkali and alkaline earth metals and their compounds, chemical combinations and decompositions separation of mixtures, pollution associated with industrial processes, catalysts and catalysis, phosphorous – compounds and properties, quantitative analysis, types of reactions.<br>Composition and uses of clay, silicates – properties, preparation of cement, Aluminium and its compounds, Calcium and its compounds. | Cement – preparation and properties, Plaster of Paris and Gypsum, Calcium and its compounds, silicates – preparation and properties, alkali and alkaline earth metals and their compounds, chemical combinations and decompositions separation of mixtures, pollution associated with industrial processes, catalysts and catalysis, phosphorous – compounds and properties, quantitative analysis, types of reactions.<br>Composition and uses of clay, silicates – properties, preparation of cement, Aluminium and its compounds, Calcium and its compounds. | Cement – preparation and properties, Plaster of Paris and Gypsum, Calcium and its compounds, silicates – preparation and properties, alkali and alkaline earth metals and their compounds, chemical combinations and decompositions separation of mixtures, pollution associated with industrial processes, catalysts and catalysis, phosphorous – compounds and properties, quantitative analysis, types of reactions.<br>Composition and uses of clay, silicates – properties, preparation of cement, Aluminium and its compounds, Calcium and its compounds. |

#### *4.2.2.2 By the students*

A practical verification of the chemistry education potential of industries is carried out by taking students to one among the selected factories for field study. The report prepared by students after field study is given below and the education potential identified is explained thereafter.

The industrial environment selected for field study by the students was Kerala State Salicylates and Chemicals Limited., Thumpa, Thiruvananthapuram.

**KERALA STATE SALICYLATES AND CHEMICALS LIMITED (KSSC), Thumpa, Thiruvananthapuram**

Kerala State Salicylates and Chemicals Limited (KSSC) was incorporated in the year 1984 as a subsidiary of Kerala State Industrial Enterprises Ltd. This company set up a plant for the manufacture of Aspirin and other allied products. In KSSC, there were three major production plants, having licensed capacity to manufacture the following.

Plant I - Salicylic acid

Plant II - Acetyl salicylic acid (Aspirin)

Plant III - Sodium Salicylate

In addition to these plants, there were two more utility plants for producing carbon dioxide and Nitrogen. Other utility plants were

i) Chilling plant – to get chilled water

ii) Compressed air plant to exert controls

iii) Water treatment plant – to prepare demineralised water used for production

iv) Effluent Treatment plant (ETP) – Treatment of waste

v) Boiler house – Boiler – 10 tonnes capacity for producing steam

A lay out of the factory, showing the stages of production of Aspirin is given in Fig. 19.

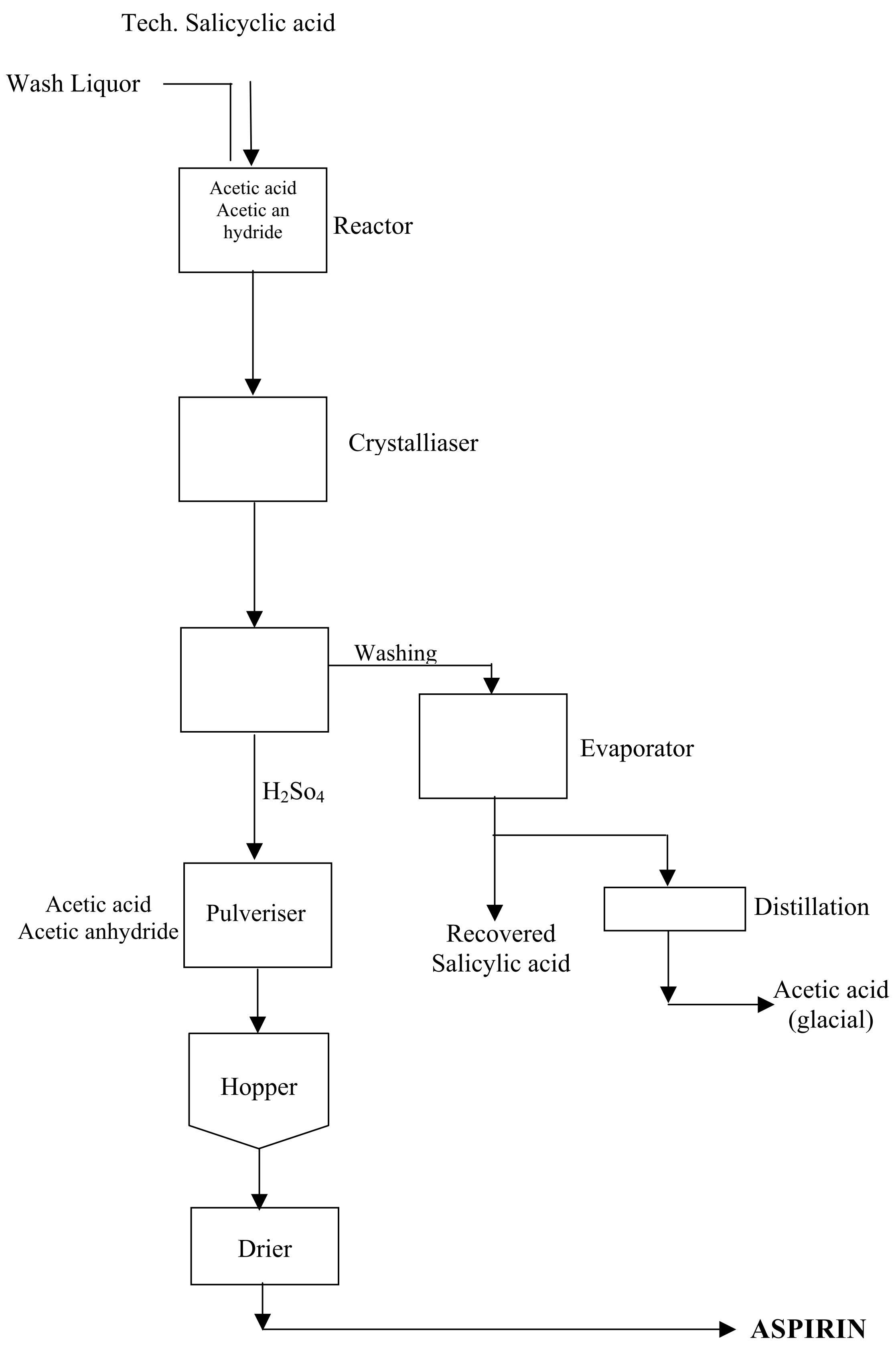


**Fig: 4.19** **Production of Aspirin**

**Acetyl Salicylic acid (Aspirin)**

**Process – General**

Aspirin (Acetyl Salicylic acid) or ortho-acetoxy benzoic acid, $CH_3COO\text{-}C_6H_4COOH$, is a versatile, safe and effective drug. It finds uses in analgesic, antipyretic and anti inflammatory applications. In the $18^{th}$ century, the Rev. Edward Stone of England found that extracts of willow bark relieved angi (rheumatic fever). Chemists later isolated the active, ingredient, put acetyl salicylic acid on the market under the name Aspirin.

The process of manufacture of Aspirin involves the reaction of salicylic acid and acetic anhydride. The reaction mixture is cooled down to crystallize out aspirin which is then dried to give the end product. The current process developed by Norwitch represents and advanced state of art in Aspirin Manufacture and has a very high yield (98%).

Main reactions are given below

$HO\text{-}C_6H_4\text{-}COOH + (CH_3CO)_2O \rightarrow 2(H_3C\text{-}COO)\text{-}C_6H_4\text{-}COOH + H_2O$

Salicylic acid    Acetic anhydride    Acetyl salicylic acid

Side reaction

$(CH_3CO)_2O + H_2O \rightarrow$ 2CH3COOH

$H_3OOC\text{-}C_6H_4\text{-}COOH \rightarrow H_3OOC\text{-}C_6H_4\text{-}COO\text{-}C_6H_4\text{-}COOH + CH_3COOH$

Acetyl salicylic salicylic acid

Process description

Steps involved

1. Batch dissolution and reaction of Salicylic acid (Tech) with acetic anhydride.
2. Batch crystallization of Aspirin.
3. Continuous evaporation and recovery of accetic acid/acetic anhydride for recycling
4. Batch hydrolysis of acid and recovery of salicylic acid.
5. Continuous drying of aspirin crystals.

**Technical salicylic acid**

Major process design consideration

1. Batchwise sodium phenate preparation prior to spray drying.
2. Provisions of 2 spray dryer feed tanks to ensure consistent quality of sod. phenate solution going to dryer.
3. Continous Spray drying of 65–67 % w/w sodium phenate solution. Fresh $N_2$ containing maximum 1 % v/v oxygen is used as make up for circulating inert gas.
4. Batch carboxylation of dried sodium phenate with $CO_2$ to produce Sodium salicylate.

5. Batch treatment of Sodium salicylate solution – dilution, neutralization with dil. Sulphuric acid, decolourising by addition of sodium hydrosulphite and versene(sodium salt of EDTA)
6. Continuous treatment of neutralised liquor for removal of coloured impurities in a carbon column.
7. Continuous precipitation of salicylic acid with dil.sulphuric acid.
8. Continuous vacuum crystallization of salicylic acid.
9. Batch centrifuging of salicylic acid slurry.
10. Continuous drying of wet crystals in a rotary steam tube dryer.
11. Storage and distribution.

**Process**

Tenneco process for manufacture of salicyclic acid involves pressure carboxylation of dry sodium phenate. The resulting crude sodium salicylate is dissolved in water, treated to eliminate colour and impurities, then acidified with dil. $H_2SO_4$ to precipitate the insoluble salicylic acid.

**Process description**

Main steps involved in the process

1. Automatic weighing (batch) system for phenol-caustic mixing to produce sodium phenate.

2. Continuous spray drying of sodium phenate (65-67% solution).
3. Batch carboxylation of dry sodium phenate in one of the two reactors to produce sodium salicylate.
4. Batch treatment of approximately 30% w/w sodium salicylate solution (detection, neutralisation with diluted $H_2SO_4$, decolourising by addition of sod hydrosulphite and versene and subsquent purification with activated carbon)
5. Continuous precipitation with dilute $H_2SO_4$ followed by vacuum crystallization.
6. Centrifuging in batch, basket type centrifuges
7. Continuous drying in a rotary steam tube dryer.
8. Screening and distribution

**Carbon dioxide ($CO_2$)**

**Preparation - Kerosene burning**

1. Firing of kerosene to a burner system and the $CO_2$ formed then is absorbed in MEA, (Mono Ethanyl Amine) at $30^{O}C$. The absorbed $CO_2$ is liberated by heating absorbed MEA.
2. $CO_2$ is compressed to 20 $Kg/cm^2$ pressure and passed through water column and dil.$KMnO_4$ solution to remove CO and suspended

impurities and is then passed through activated alumina to get dry $CO_2$. This $CO_2$ is further compressed and stored in a refrigerated condition at $-4^0$c by using refrigeration compressor and is stored in liquid state at $-20^0$C. Before releasing to the plant for carboxylation, liquid $CO_2$ is passed through a water heat exchanger to convert it to vapour state and $CO_2$ at 2 Kg pressure and atmospheric temperature is applied to the plant. Kerosene is used since the burnt out $CO_2$ will not have any $SO_2$ or $H_2S$ that can occur if diesel or any other fuel is used.

**Nitrogen ($N_2$)**

**Preparation – Atmospheric air compression**

Air compressed to 8 kg pressure- dehumidized by passing through activated alumina column and is sent to the selective absorber (Molecular sieve) (pressure sewing absorber), during absorption oxygen is released leaving $N_2$ which is stored in 6 Kg pressure.

**Learning outcomes – An analysis**

The chemistry education potential of KSSC, identified after field study by the students, is presented in terms of their learning outcomes as given below:

- ★ Pupils were made familiar to the production of a commonly used drug, Aspirin. They were able to learn the chemistry involved in the manufacture of the drug and the technical processes used for production.
- ★ Even though the major product manufactured is Aspirin, there are four more production units. Thus pupils were able to experience five different processes of manufacturing and learn the chemical concepts involved.
- ★ Pupils were able to integrate the concepts involved in each process of production and their interrelationship in a comprehensive manner.
- ★ Pupils were able to identify some production processes from easily available resources like Carbon dioxide from kerosene, Nitrogen from atmospheric air etc.
- ★ Pupils were able to develop skill in observation, communication, experimentation, report writing etc. as evident from the evaluation of their reports.

### 4.2.3 Outcomes of the field studies.

The investigator made an analysis of the outcomes of the field studies conducted, by her and by the students, in order to identify the efficiency as well as deficiency in using industry as an outdoor learning centre. The outcomes helped in verifying the hypotheses of the study and in suggesting better means for using the chemistry education potential of an industry. These served also as guidelines for developing the ABL Model.

***a) Aspects of the utility of the industrial environment identified***

- ✦ Ample opportunities were available for students to learn varied topics in the same context and in direct contact with the learning environment. Thus more the number of production units, higher the chances for learning varied and interrelated chemical concepts in the same learning environment.
- ✦ More the number of production units, higher the chances of learning varied and inter-related concepts in the same learning environment.
- ✦ Students were taken to the factory for a particular period of time to teach as many topics as possible, thus utilizing the time and resources available to the maximum extent possible.
- ✦ Students got acquainted with the working condition, safety precautions, methods of production, etc., which they can relate to their theoretical studies.
- ✦ The kind of practical learning students receive includes subjects which give pupils a wide background of industrial chemical knowledge and skills.

- ✦ Pupils can extend the techniques of analysis that they learn in the school laboratory by making use of a variety of instruments too expensive for a school laboratory but readily available in industry.
- ✦ Students were able to co-ordinate the chemical concepts behind each production/process in a logical manner.
- ✦ Students were able to identify the complexities in connection with industrial preparation and the problems caused in the normal life of people.
- ✦ Pupils got opportunities for carrying out investigation to know better the content and ideas being discussed in books and to see science and technology in action.
- ✦ Concepts and procedures were introduced through practical contexts within which the students learn and from which they were expected to anchor and generalize their learning.
- ✦ The complicated site operations and behaviours at site can be explained in lesser time and the students will grasp in more at site instead of sitting and hearing the lecture in the classrom.
- ✦ The idea of building up from the pupils' understanding lies at the heart of the constructivist view of how pupils learn. This focuses on how pupils actively construct new understanding by relating learning experiences to their previous understanding.

***b) Intricacies associated with learning in an industrial environment.***

- When students visit the industries, they find much difference in their learning in an industrial set up and in a classroom climate.
- All students may not be able to observe and record in the same pace as the potential of students differs from one another. So further explanations or feedback for the practical experiences is necessary for better learning.
- Effective teaching of theoretical concepts in the industrial environment is not as easy as in a classroom and hence a shift towards learning rather than training or teaching is necessary. Hence anchoring of the theoretical concepts should again be done in the classroom, through reflection, based on the practical experiences they get from the industrial environment.
- Sometimes the staff of the factory may not be competent enough to explain the scientific concepts to the students, for proper learning. For example, all chemical reactions taking place in the production of aspirin and salicylic acid were not explained by the people engaged in that work.
- The manipulation of technical equipment however, ought to raise questions in the minds of students about the development of concepts regarding the phenomenon in question. For example,

preparation on $CO_2$ from kerosene is different from the method commonly used. Pupils were able to observe and experience the equipment and production processes involved which are not familiar to them.

- The content and procedures involved in learning were quite diverse and deal with a wide spectrum of perceptual, motor, verbal and conceptual domains of experience. So it is necessary to establish a climate for experiential learning stressing self-control and responsibility. Students might be involved in planning and selecting their experiences with care. They must be given opportunities to learn, to organize and co-ordinate field activities
- The collection of scientific concepts and coordinating them in an industrial environment is found to be insufficient in making use of the education potential of the industry, for learning chemical concepts, to the maximum extent possible. In this situation students must organize and evaluate the ideas received and derive more scientific concepts in the light of their experiences. Conceptualizing the experiences may be done in the reflection session, after the visit.
- Activities which enable regular practice of what has already learned are also very important There is a need to ensure that the learning is 'well learned' through appropriate practice and should be done using a variety of examples where that learning is relevant.

**The outcomes of field studies** summarized can thus be presented as:

- Majority of the topics in the HSS curriculum were found to be related to the chemical processes and principles applied in the industrial fields. This shows the relevance of using industrial environments for learning chemistry at school level.
- A very large section of the chemical industry relies upon just five basic raw materials for its huge range of products: (i) crude oil/ natural gas; (ii). Ores and minerals (salt, lime stone, metallic ores, sulphur); (iii). Water; (iv). Air; (v). energy.
- The analysis revealed the abundance of applied concepts of chemistry in the curriculum, as evident from the chemistry education potential of different industrial sectors identified earlier, and this necessitates more opportunities for activity-oriented and reflective learning than is available now.
- The curriculum should include at least one outdoor class a week. Children should be taken out of the classroom and have a feel of the local environment and taught using the locally available resources.
- Students can be sensitized to environmental problems through observation and activities and this can be effectively done through experiential learning than through formal classroom teaching.
- Educational institutions in the higher and technical level only avail the facilities of the industrial environments for training of students

in the form of apprenticeship. The general education system rarely makes use of these facilities for student learning.

✠ The formal apprenticeship provided to students, usually in technical courses, is only for a very limited period of time. They consider it as simply a routine work to be completed within a particular course of study and is being conducted at the end of the course. If we are able to provide apprenticeship-based learning during the course itself, it will be highly motivational for the students. Students may have opportunities to interact with industrial environments occasionally and be aware of the working conditions and services rendered by these industries.

✠ Many of the practical experiences, that pupil gain in the industrial environment, can be repeated in the laboratories in a simplified manner. For e.g. reactions of acetic acid and salicylic acid, preparation of nitrogen and the like.

✠ Based on the field studies conducted, the chemistry curriculum was examined for the importance given for industrial topics. It was found that the curriculum should include more industrial topics than theoretical ones and within the existing framework and the school industry links should be promoted, for learning these effectively, to the maximum extent possible.

- ✠ Another striking observation is that a considerable number of industries has locked out within this period of study itself. Many other industries are under the threat of being closed soon or later. Ill structured administration and excessive political interferences are found to be the major reasons for this pathetic condition. Moreover the outside community lacks the awareness regarding the working conditions of these industries.
- ✠ It was found that the closing down of industries adversely affected the apprenticeship training programmes of nearby institutions.

Thus industrial environments are found to be highly useful for imparting chemistry education at school level. Taking into consideration the intricacies associated with learning in an industrial environment, it was assumed that an apprenticeship-based learning is essential before a chance for actual, formal apprenticeship and a four-stage model was suggested.

Development of field-based skill, increased self confidence for undertaking field work, testing opportunity of theory with live problems and exposure to real problem solving techniques, development of work culture etc. are some of the expected outcomes of such learning. For ATL, the teacher should visit the industrial environment in advance, identify processes and products, find areas in all sections of chemistry, prepare lessons, etc. This demands genuine and creative work on the part of the teacher.

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# APPRENTICESHIP-TYPE LEARNING (ATL MODEL)

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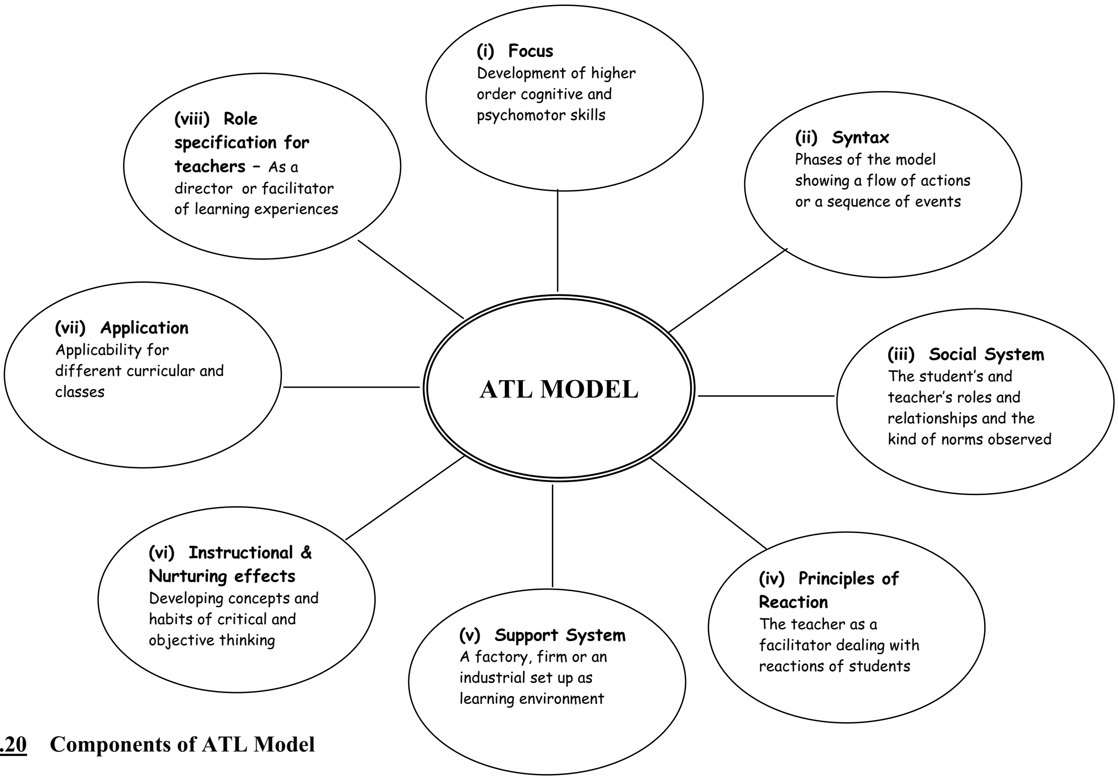
## 4.3. Preparation and description of the ATL Model

Developing a model can be seen as a search for a description or even a ‘cause’ for an observed fact, as constructing a design for something which does not exist, or for developing a plan for action. Apprenticeship-Based Learning (ABL) is a type of quality learning because it follows a specific plan that is built on meaningful ‘strategic learning (Walker, 1998)’.

### 4.3.1 Components of ATL Model

According to Joyce & Weil (1990), each model of teaching has a theory and a practical training. To translate theory into practical form, there are certain concepts called components or the fundamental elements of a teaching model.

The components of ABL model are diagrammatically represented in Figure 4.20.




**<u>Figure 4.20</u>  Components of ATL Model**

### *4.3.1.1. Description of the components*

**(i)** ***Focus*:**

*This model aims at developing higher order cognitive and psychomotor skills in students. They are allowed to learn in an environment where they observe and practise the learning activities. In this study an apprenticeship-based environment will be created so as to enable the pupils to learn in the context of observing, interacting and doing. Better learning will not come from finding better ways for the teacher to instruct, but from giving the learner better opportunities to construct (Papert, 1991). Thus concepts and procedures will be introduced in a practical context within which the students learn, and from which they are expected to anchor and generalize their learning.*

**(ii)** ***Syntax***

It describes the phases of the model. If involves the description or structure of activities and presents the model as a flow of actions or a sequence of events. The ABL model consists of four phases arranged in an integrated and sequential manner. These phases are sequenced in the order given below

**Phase I** ***Procedure Design Phase***

*Major activities - (i) Preliminary Information.*

*(ii) Planning and Preparation for ATL*

**Phase II** ***Apprenticeship-Based Learning (ATL) – Observation and Activity Phase***

*Major activities- (i) Learning environment - observation by students*

*(ii) Learning through Apprenticeship*

*(iii) Checking the progress and recording of activities.*

**Phase III** ***Reflection and Idea Generating Phase***

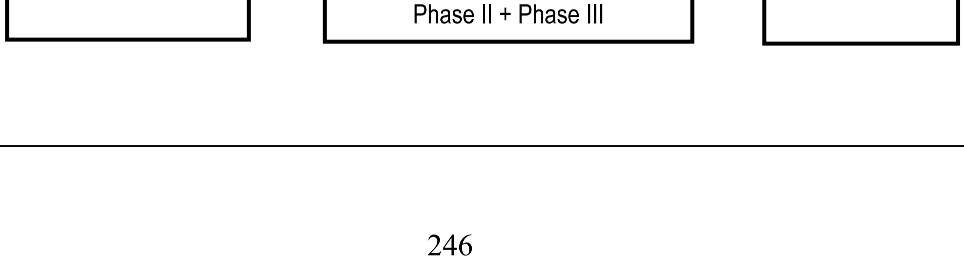
*Major activities- (i) Discussion on student- record of activities*

*(ii) Rectification of errors and remediation*

*(iii) Conclusion and summary of learning*

**Phase IV** ***Evaluation and Extension***

*These phases in the strategy can be diagrammatically represented as*



Each phase has definite objectives, series of learning events and evaluation procedures. Students are given a theoretical background of what is to be learned. They are then taken to the environment where they can learn while observing, doing, interacting and reflecting on experiences gained. Pupils observe things, machines and equipments, their working procedures and processes adopted in the industry and thus develop cognitive as well as psychomotor skills. It proceeds through different stages with the assistance and guidance of the teacher and staff.

***(iii) Social System***

*It describes the students' and teacher's roles and relationships and the kind of norms that are encouraged. Students in ABL model are active participants in the teaching-learning process. They are taken to an environment, where they can learn and practise simultaneously. The teacher's role is to discuss with the students what they are going to learn. Teachers guide the students in their activities and experiences that help them generate knowledge by reflection. In the ABL model, students are expected to receive a type of on-the-job learning.*

***(iv) Principles of Reaction***

*It explains the procedure in which the teacher deals with the reactions of the students. Here the teacher is a facilitator, a coach and a cognitive mentor. Pupils are provided with opportunities to 'discover' actively what is to be learned and for such learning to become meaningful to them, allowing them to 'construct' their understanding through their own effort. This more active approach is important in providing motivation for pupils by linking the more open-ended and problem solving approach to the pupils' natural sense of curiosity and exploration*

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***(v) Support System***

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*It deals with the use of other teaching aids, human skills and capabilities and technical facilities. For learning through ABL model, students are taken to a factory, firm or industrial set up where they can observe and learn the different activities and background knowledge involved in functioning of that set up. They learn in the context of observing, reflecting and doing, i.e. in an Apprenticeship based mode*

Innovative teaching-learning techniques, objective assessment and communication, matching of functions with aptitude and capability, autonomy to the learner and support from the teacher, team work and suitably designed changes in environment were some factors that can act as motivating factors in the learning through ABL model.

***(vi) Instructional and Nurturing Effects***

*It describes the direct and implicit results of instruction. Learning through ABL model provides practice in inductive reasoning and opportunities for altering and improving students' concept-building strategies. It is an attempt to form a bridge between theory and practice, academic education and vocational sector, school and life. The model is expected to nurture interest of inquiry and develop precise habits of thinking. This might develop critical and objective thinking. It wants the student to appreciate the relationship between the individual and the natural, technological and social environment*

***(vii) Application***

*It deals with the further applicability of the model for different curricula and classes. The aim of the model is to give the student as firm a grasp of a subject as it can, and to make him autonomous and self propelled, a thinker who will go along on his own even after formal training has ended. It prepares (or aims at preparing) an individual to fit into a team, to lead him towards a goal. The programme is extremely flexible - because it may be used alone, or in conjunction with their teaching techniques. Since the world of work cannot be brought into the school room, the school must go out to the world's work*

***(viii) Role Specification for the teachers***

> *The teacher's most important role is that of instructional designer. As a designer the teacher recognizes the centrality of planning, structuring, provisioning and orchestrating learning. As Gerlach et al (1980) suggested, the teacher should become a director or facilitator of learning experiences*

The teacher has to focus on the following points / questions while designing learning.

- How might learning environments be selected or constructed for learning specific content area?
- What contents, ideas and / or concepts afford a context for student learning?
- What foundations of learning do students need to learn?
- Which activities should be chosen to ensure that students become actively engaged in learning through construction?
- What tools might a designer choose to best support and enhance student learning?
- What system of assessment might be constructed to appropriately assess student learning?

Hence the intellectual analysis of content filtered through an understanding of learning and learners and the subsequent construction of learning opportunities for students underpins all robust and worthwhile learning opportunities. Teacher's choices about the types and organization of learning environments are closely related to what and how students will learn.

### 4.3.2 Description of the phases of the model

***Phase I Procedure Design Phase***

The major activities include:

(i). giving preliminary information - regarding the topic to be studied, the industrial environment to be selected for model-based learning, the general features of the site, the activities to be organized for learning through ABL etc. and

(ii). planning and preparation for ABL - preparation of the materials, resources and progressions that will be needed in the lessons/activities. Deep content understanding is a pre-requisite for designing good learning activities. Hence the teacher has to conduct the field study of a suitable learning environment before planning for ABL. If the materials are prepared prior to instruction, the teacher is in a much better position to successfully differentiate the activities, as well as to cope with maintaining the smooth and effective progress in learning through out the work for all pupils. Thus planning and preparation include

- Organization of students into groups - The objectives determines group size.

- Allocation of time - the plan for use of time will vary according to the quantity of subject matter area, objectives, space availability, administrative patterns, and the abilities and interests of students. The teaching plan should take into account the estimated time for each type of activity.

- Discussion with students the objectives and expected learning outcomes - the handling of work, behaviour codes, etc.

- Explain to students the nature of what is to be covered in a particular session and how this relates to the rest of their course.

- Explain clearly (and review at intervals) the assessment procedure that will operate - this include both formal and informal evaluation techniques. Students will be able to articulate their learning needs and identify and discuss any barriers which might prevent them from learning.

***Phase II Observation and Activity Phase***

The earlier phase serves a preparation for making empirical observation and the remaining phases focus on using these observations (i.e. processing, understanding and communicating them)

During this phase, instructional manipulations and learning experiences take place and proceed through various stages of learning. It is the point/phase at which students confront the content and begin to move towards the defined objectives. It is necessary to establish a climate for experiential learning, stressing self control and responsibility. Learning by experience implies learning from the pressure of practical situations or environmental conditions in which pupils find them. Experience determines the directions in which instinct may profitably be expressed. The teacher must remain the figure of authority, guiding and supervising.

From time to time students come together in groups, but the primary orientation is towards individual study. The focus is on the rate at which students proceed through a carefully sequenced series of behaviourally defined objectives (for each area). The provision for difference in the rate of learning involves more than permitting pupils to work as fast as they can. It also involves the determination of how much exposure to content is required so that an individual pupil will achieve mastery of that content.

All investigations should be summed up by making a record of what was done. It involves individual prescriptions/decisions for each student in the programme at each stage in the learning sequence/ learning processes. Recording provides a visual check on work completed, nature of the task and a rough guide to overall progress.

At the end of this phase pupils will be able to develop

- ❖ knowledge of apparatus and materials used for manufacture, nature, composition and use of product obtained.
- ❖ knowledge of processes, procedures for preparation, finding composition, locating errors, chemical reactions involved in the manufacture, energy changes taking place during the processes etc.
- ❖ knowledge of scientific concepts, principles underlying each and every reaction; process procedures etc.
- ❖ understanding of industrial set up - different aspects of manufacture - cost, production, supply, efficiency of materials, etc.
- ❖ skills in communication, observation, manipulation, cognition, etc.
- ❖ attitude to work with others and peers with a sense of community and shared feeling

- the student's independent research skills
- the quality of preparing and keeping record of activities
- respect for individuals within the learning community
- improve the level of written work among the students in general and
- student's confidence outside the classroom

***Phase III  Reflection and Idea Generating Phase***

Opportunities for reflection are a necessary part of every teaching-learning programme and need to be created, protected and used to provide the students with feedback on their progress as well as to ensure that the teachers are in touch with the learning which is taking place.

During this phase, students are helped to reflect on their learning. This is a time of metacognition in which students evaluate the learning and its meaning to their world. Pupils' learning can be improved if they are helped to think about the way they learn and to develop methods of making their learning explicit (Adey & Shayer, 1994). To help pupils think about the way they learn, they are encouraged to describe their observations, verbally or pictorially. They are helped to express these ideas clearly, in order to recognize what they can and cannot explain.

Thus this phase includes a period of review at the end of a lesson or activity in which pupils were briefed about what they have learned. This enables pupils to assess their performance and learn from mistakes, and enables teachers to check whether their teaching has been successful (Brophy and Allen man, 1991). Effective learning emphasizes facilitation of understanding through critical reflection and discourse.

Reviewing include asking pupils to review their own progress and to identify aspects of their work. The teacher wants the pupils to rearrange ideas, make logical combination of materials and fill in gaps in meaning or even to create solutions to problems. Once students' inferences are validated by data, the teacher can bring the lesson to a closure by verifying the abstraction, asking students to verbalize it, prepare a comprehensive note on the concepts learned and by presenting additional examples to reinforce student learning. The teacher, then, will be able to correlate more related topics with the scientific processes carried out in the industrial environment.

Reviewing seems to be effective in helping pupils consolidate their learning by being more aware of learning outcomes that have occurred. Much of this learning has been stimulated by the development of new forms of recording pupils' progress through profiling and recording of achievement. By this approach, the practical work has led to the theory. The concrete experience of the practical work will enable the pupils to get a feel for the phenomena. This encourage pupils' self-evaluation and to some extent, the negotiation of target for their own learning. Thus while learning through ABL, concept learning can be achieved by exposing alternative frameworks, creating conceptual conflict, and encouraging cognitive accommodation.

**Reflection on the Learning Experiences –** will help pupils to develop

i) confidence in sharing their ideas and actively contribute to the learning situation

ii) their ability in a number of core skills in communication

iii) cognitive skills like

- a) recall of knowledge and procedure
- b) providing his or her own examples - perhaps by reporting his or her own observation and experience in terms of new connections made
- c) application of knowledge gained in a novel situation
- d) interpreting information
- e) analysis of data
- f) synthesis of data
- g) evaluating ideas of another person and

iv) practise cognitive apprenticeship based learning by

- a) reporting his or her own observations and experiences in everyday terms.

b) pick out, restate or remember important facts, concepts or principles that have been presented

c) distinguishing between given examples and non examples of new concepts and principles that have been presented.

d) applying the new concepts, principles (plus native wit and personal experiences) to analyze, interpret or plan a new situation.

v) identify and discuss any barriers which might prevent them from learning and

vi) demonstrate skill in critical thinking.

***Phase IV – Evaluation and Extension***

The final step in the implementation phase of the model is the presentation of additional data which directs towards transfer of learning.

**Evaluation**

During the instructional phase, testing and evaluation provide means of assessing students' learning. Observing students' behaviour in natural surroundings, without manipulation or attempts to control other factors, means that what we see will be a product of many interactions. Evaluation of the learning, by the pupils and by the teacher in each lesson is an essential part of the process of teaching if there is to be a progression in learning. On the basis of this evaluation, the nature, structure and content of future lessons can be appropriately enhanced.

Record keeping helps monitoring and assessment with reporting. Informal assessment takes place as part of the activities and processes and it is usually observational where the teacher and the staff observes performance of students and make notes for future reference. Formal assessment is made following prior warning that assessment will occur. This gives pupils the opportunity to revise and prepare for the assessment process. Internal assessment forms an important part of the system of assessing students' performance during the course of study. It helps providing information to learners on their progress in learning as well as their achievement of the intended instructional objectives.

**Feedback**

The concept of feedback used here implies a confirmation or correction. The term is useful in instruction as it implies an evaluation of the product or terminal behaviour in direct relation to the original objective.

### 4.3.3 Characteristics of the ATL Model

- Learning takes in a context. Learning in an apprenticeship type of environment can be quite natural and excellent as the real learning situation provides direct and first hand experiences and allows the child to learn in his own way.
- The model provides opportunities for on-the-job learning and automatic processing of information may take place so that students will be able to exhibit some skills in his/her own way.

- There is an emphasis on depth learning through reflection on learning experiences, rather than covering a great deal of material.
- Students can be provided with meaningful, challenging work. Higher order thinking is emphasized for everyone.
- Connections are made to the real world and between learning in and outside the school.
- The model includes cognitive apprenticeship which combines strategy training with skills such as social interaction, observation, practice and reflection.
- Assessment is a natural progression of the lesson, not something is tacked on at the end.
- The learning environment emphasizes collaboration and dialogue. To be successful in the job market, students must be able to articulate what they know and listen to the ideas and options of others. The act of sharing of ideas, having put one's own view clearly to others, of finding defensible compromises and conclusions, is in itself educative.

## 4.4. Preparation of lessons based on ATL Model – for learning the topic 'Cement'

An Apprenticeship-Type Learning Model for learning a particular topic in chemistry is developed as per the details given below.

### 4.4.1 Industrial environment selected.

The industrial environment selected for learning through ABL Model was The Travancore Cements Limited, Kottayam. The investigator conducted field study of three Cement factories. Among them, this factory is found to produce ***White cement*** and is the only factory producing white cement in south India. The other two factories produce the commonly used varieties of cement. Thus pupils will have the benefit of experiencing the production of special quality cement. This motivated the investigator to select the industrial environment for pupils to learn through ATL Model. The field study report of The Travancore Cements, Kottayam is given below.

#### *4.4.1.1. Field study report of The Travancore Cements, Kottayam*

The Travancore Cements Ltd. at Nattakom, Kottayam has been a pioneering venture in cement production. Established in 1946, the company started manufacturing grey cement in 1949. A decade later in 1959- the company embarked on the production of white cement devoting a few months in an year for the purpose. In the year 1974 the company switched over to the exclusive manufacture of the white cement. In 1977 the company started the production of cement paint.

**Major products**

The products of the company are “VEMBANAD” brand white cement, grey cement and “SUPER SHELCEM” cement paint.

**Raw materials for white cement**

The main raw materials are lime shell, white clay, white sand and crystal gypsum.

A) Lime shell – lime shells are found as under water deposits in the vembanad lake. Almost 99 % accounts for calcium carbonate ($CaCO_3$) while the presence of usual impurities like iron compounds and magnesia is negligibly insignificant. White Portland cement has the distinction of being the only cement that is manufactured from lime shell.

B) White clay – almost 97 % pure hydrated aluminium silicate

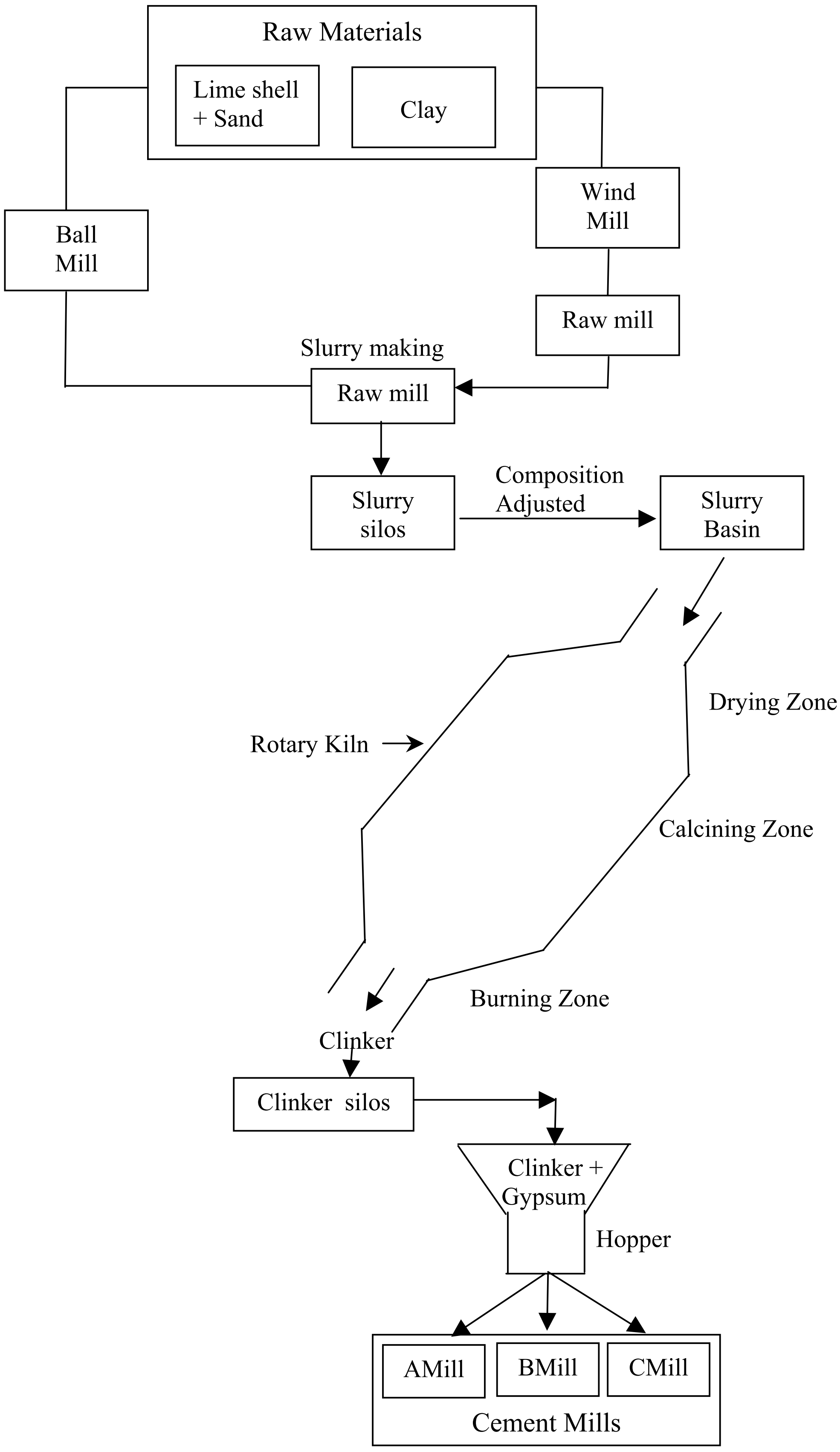
C) White sand - with purity upto 99%

D) Crystal gypsum – purity maintained above 95% the crystalline gypsum.

**Process of manufacture**

The Travancore cements produces VEMBANAD white cement using the rotary kiln and **wet process technology**.

The basic cement making process consists in collecting the raw materials, grinding them to a fine stage, blending them to a uniform composition and heating them to the point of incipient fusion when the cement compounds are formed. Portland cement is the product obtained by cooling and grinding the clinker thus formed with gypsum to a fine powder. A diagrammatic representation of the production of white cement is presented in figure 4.21.




**<u>Figure: 4.21</u>    Diagram showing the preparation of 'White cement'**

Production processes can be mainly divided into three stages:

1. Slurry preparation
2. Clinker making
3. Clinker grinding

**Wash Mill**

Before actually used for process, the clay is making to mix with water, in a clay wash mill. Clay is made to a pasty form, known as clay slurry. This clay slurry is pumped to the storage tank known as silo; there it is taken for process when required.

For the slurry preparation two grinding mills are used.

1. Roughing mill known as ball mill
2. Finishing mill known as raw mill

The shell along with required amount of white sand and water is fed to the ball mill by a rotating feed table. The mill is partially filled with steel balls as grinding media. When the mill rotates, the materials are crushed down to small particles while it passes through the balls. The materials coming out of the ball mill is diverted to a hummer screen by means of a slurry elevator. Fine particles sieves out the hummer screen are fed to the raw mill. The coarse materials return to the ball mill for further grinding.

The mill is rotated by a motor at constant speed. While passing through the mill, the fine materials discharged from ball mill and clay pumped from clay silo are finely ground and comes out as a pasty material known as the slurry, which then flows to the slurry pit.

The chemical composition of the slurry will be adjusted at this stage. There are three silos for storing one of which is an ordinary well type tank. Slurry is constantly agitated with compressed air and stirring mechanism in order to avoid solidification. From this basin slurry is taken for burning in the kiln.

**Clinker making (kiln)**

Kiln is a cylindrical steel shell, lined with refractory bricks. The kiln is having a length of about 285 feet with diameter of about 9.a.m and is rotated at about 1 rpm by an electric motor. Kiln is fed with slurry at the upper end by a scoop feeder. Since the feeder is synchronized with the kiln, it will deliver only slurry proportional to the speed of kiln. During the burning process, the slurry passes through three stages or zones:

| | | | |
|---|---|---|---|
| 1. | Drying zone | - | driving off water content |
| 2. | Calcining zone | - | driving off $co_2$ at about $1000^0$ c |
| 3. | Burning zone | - | burning at about $1400^0$c |

As the kiln rotates, the bed of slurry rotates over the surface of lining. In the drying zone, about 99% of the water content in slurry will removed. In the calcining zone, removal of $co_2$ takes place.

$$CaCO_3 \rightarrow CaO + CO_2$$

After passing through the calcining zone, the materials enter the burning zone. The clinker is formed in the burning zone by fusing the compounds $C_2S$ (dicalcium silicate), $C_3S$(tricalcium silicate) $C_4AF$ (tetra calcium alumino ferrite) at about $1400^0$c. At this temperature, the coloured ferric oxide of iron is bleached to light green in colour. For this colour change, a reducing atmosphere is created by spraying l d oil to burned clinker. The burned clinker is then quenched by means of a spray of water. The steam produced from this water creates a reducing atmosphere in kiln which speeds the conversion of $fe_20_3$ to feo. Also it prevents the reverse reaction. The clinker then flows to nine coolers connected on kiln's periphery. Clinker coming out of the coler will be usually in the nodular form. The clinker from the cooler, flows to the crusher hammer where the bigger pieces are broken down to the required sizes. Clinker from crusher hammer is conveyed to storage silos. Clinker for grinding is taken from these silos.

**Clinker grinding (cement mills)**

A grinding mill similar to the one used for finishing grinding of raw materials is used for clinker grinding. Clinker is harder than raw materials and has to be ground finer so that the output from a mill of same size is smaller. There are three clinker grinding mills namely a mill, b mill, c mill.

**A mill**

A mill has got two chambers charged with flint pebbles of different sizes as grinding media. In the first chamber bigger grinding media is put to crush down the hard clinker. In the second chamber flint pebbles of smaller size is charged for final grinding of clinker. Felcite blocks are used as liners in a mill. The temperature of cement during grinding should not exceed $1000^0$c or the gypsum may7 be dehydrated as plaster of paris which affects the setting properties of cement. So the cement is to be cooled. These are attained by the stream of air used for the ventillation of the mill and while the cement passing through the elevation, separator, and the conveyors. Clinker from silo is conveyed to the clinker hopper using a chute. Gypsum is also stored in a hopper near the clinker hopper. There are two laminated feeders beneath these hoppers. The mill is rotated at constant speed by an electric motor. Clinker with 4% gypsum is fed to the mill with laminated feeder. The ground material (cement) coming out of the mill is conveyed to the classifier known as separator by means of a bucket elevator. The flux pump is a pump used for pumping cement to the storage silos. Compressed air is passed to the flux pump which carry the cement to the top of silo. There are two cement silos inside the packing house. From these silos the packing machine draws cement for packing.

B mill and c mill are two identical mills which has got three chambers. Clinker and gypsum in the correct proportion is fed to the b mill by means of rotating feed tables. A screw conveyor is provided from these feed tables to c mill to feed the same. The ground cement flows to the flux pump and then to the cement silos.

**Packing and despatch**

The white cement stored in silos is packed in bags with capacity (50kg) in the packing house. Paper gunny bags of superior quality are used for packing white cement.

**Outstanding qualities of vembanad**

1. **Lowest magnesia (Mgo) content**

   Mgo is the ingredient which affects the durability of cement. Vembanad has the lowest mgo content; the reason why vembanad is the most durable white cement.

**2. Brilliant whiteness.**

The perfect, permanent whiteness of Vembanad makes it the ideal basis for manufacture of any shade of cement paint, especially the pastel shades.

**3. High strength**

Vembanad - white cement has all the excellent qualities of high strength cement. It sets very hard and develops high strength cement. It sets very hard and develops high strength very easily. At the end of the 1st day, the strength exceeds what is specified to acquire at the end of the 3rd day.

**4. Super soundness**

Due to the least Mgo content, the soundness behaviour of vembanad, white cement is superb.

**5. Super fineness workability**

Vembanad white cement is available in a supreme fine mesh size, with a specific surface of 4500-4600 sq.cm/gm providing the highest workability standards to this cement.

**6. Setting properties**

Due to the special chemical formulae of Vembanad it is ideal cement for manufacture of cement paint with self curing properties.

The high tricalcium silicate and aluminate content of vembanad make it possible for the cement paint to set quickly and properly on the walls within 4 –6 hours. Curing with water can be avoided for cement paints manufactured using Vembanad and suitable chemicals and pigments.

**Manufacture of Grey Cement**

The process of manufacture and the machineries involved in Grey cement production are same as that of white cement. Since the presence of iron in raw materials will not matter much as in white cement, the selection of raw materials is comparatively easier for grey cement. Unwashed shell, ordinary Laterite, and river sand are the raw materials used. The finishing, grinding of raw materials done in a tube mill, lined with steel linings and charged with steel grinding media as against Felcite stone lining and flint pebble grinding media for white cement slurry production. Since steel grinding media is use, the output of the mill is much larger than white cement raw mill. After burning the slurry in the klin, clinker is not bleached as in white cement. Clinker is cooled only by air supply. Coal powder with furnace oil is used as fuel. The clinker grinding mill is linked with manganese steel lining plate and charged with steel grinding media. The pumping of cement to the silos is done with the fluxo pumps. From these silos the packing machine draws cement for packing in gunny bags for despatch.

**'Super Shelcem'- Cement Paint**

The travancore cements ltd. Produce a cement paint in the brand super shelcem. The main ingredient of this paint is the vembanad white cement. Along with white cement, some chemicals, colouring pigments, grey cement, lime powder, clay powder and fungicides are added in the required proportion. They are thoroughly mixed and ground to a fine powder in a ball mill for about 4 hours. Some of the chemicals used are titanium dioxide, calcium chloride, aluminium stearate etc.

There are 40 shades of cement paint are produced here. The outstanding properties of super shelcem are :

1. Water proofing : shields the walls from monsoon and fungus.
2. Opacity : just two coats are enough for super finish and galze.
3. Coverage : 1 kg of super shelcem can cover 160 sq. Ft for a single coat or 80 – 100 sq.ft for two coats.
4. Adhesion : applicable on cement, plaster, concrete, brick works, stone and lime plastered surface.
5. Drying : super shelcem dries rapidly and the second coat can be applied 3 – 6 hours after painting the first coat.
6. Self curing : it has got the most self curing properties.

The report is prepared and presented in a comprehensive manner.

### 4.4.2 Selection of contents in the HSS curriculum

The content selected for study, was the "Preparation of Cement" given the Chemistry text of Higher Secondary- Std. XI. The topic is selected with a view to give the students a clear and comprehensive idea of the manufacturing of cement. Even though cement is widely used for construction purposes, pupils are not aware of the chemical processes behind the production of cement. When they are taken to a factory; they get direct experiences regarding the various stages of production and the chemical processes behind each stage in detail. The content areas selected for instruction through ABL model, after identifying the chemistry education potential of the industrial environment, are presented in the unit plan.

### 4.4.3 Preparation of Unit Plan

A unit plan for learning the topics selected was prepared based on the objectives of instruction using ABL Model, specifying the strategies for learning, divisions of students into groups, allocation of time and evaluation procedures. The major unit selected for the study was 'Preparation and Properties of Cement'. The large content area was divided into subunits as given in Table 4.7.

***Table 47***

***Sub units included in the Unit plan***

| | |
|---|---|
| Sub units 1 | Cement industry – Composition of cement – Types of Cement – Introduction |
| Sub units 2 | Manufacture of Cement – White Cement |
| Stage (i) | Grinding of raw materials using wet process |
| Stage (ii) | Production of cement clinker |
| Stage (iii) | Production of Cement |
| Sub unit 3 | Setting and hardening of cement |
| Sub unit 4 | Concrete |
| Sub unit 5 | Properties of white cement |
| Sub unit 6 | Preparation of Portland cement |
| Sub unit 7 | Cement paint |
| Sub unit 8 | Lime – Manufacture and properties |
| Sub unit 9 | Plaster of Paris – preparation and properties |
| Sub unit 10 | Preparation and properties of metallic calcium. |

The unit plan along with a sample lesson is given in the next section.

### 4.4.4. Preparation of Lesson plans

Based on the unit plan (given below) and the education potential of the learning environment, a detailed plan of activities (lesson plans), for learning through the ABL Model developed, was prepared. The lessons are presented in the Appendix and a sample lesson is presented after unit plan. The details are given as follows:

## UNIT PLAN

| | | | |
|---|---|---|---|
| Subject | : | Chemistry | Std. XI |
| Unit | : | Cement | Duration –15 hrs |

**Major unit: Preparation and Properties of cement**.

**Sub units**

| | |
|---|---|
| Sub Unit I | Composition of Cement |
| Sub Unit II | Manufacture of cement |
| State(i) | Grinding of raw materials using either dry process or wet process |
| Stage (ii) | Production of cement linker |
| State (iii) | Production of cement |
| Sub Unit III | Setting and hardening of cement |
| Sub Unit IV | Concrete |
| Sub Unit V | Properties of white cement |
| Sub Unit VI | Preparation of Portland cement |
| Sub Unit VII | Plaster of Paris – preparation and properties |
| Sub Unit VIII | Lime – Manufacture and properties |
| Sub Unit IX | Cement paint |
| Sub Unit X | Preparation and properties of metallic calcium |

**Major Objectives and learning outcomes.**

Students will be able to develop

**I. Knowledge of**

***Facts***

i) Cement has the property of setting to a hard mass after being mixed with water.

ii) There are different types of cement depending upon the constituents present in cement.

iii) Cement is essentially a mixture of calcium silicate and calcium aluminate with small amounts of gypsum

iv) The ratio of alumina to silica which lies between 4 and 2.5.

v) The ratio of calcium oxide to silica + alumina + ferric oxide should be as close to 2 as possible. In white cement, the amount of ferric oxide is negligible.

vi) If lime is in excess, the cement cracks during setting.

vii) If lime is less than required as given in the ratio; the cement is weak in strength.

viii) Concrete is a mixture of cement with sand and ballast or aggregates of crushed stone.

ix) Setting of cement is an exothermic process

x) Concrete is used for constructing buildings, roads, bridges etc

xi) There are different types of cement having slight difference in this composition.

***Concepts***

i) The essential constituents of cement are lime, silica, aluminum oxide, magnesium oxide and ferric oxide. Different types of cement vary in their composition slightly.

ii) There exists a fixed ratio among the constituents of cement which determines its strength

iii) Either wet process or dry process is used in the manufacture of cement depending on the nature and hardness of raw materials.

iv) During the manufacture of cement, chemical combination of constituents takes place by applying a wide range of temperature.

v) The hardening of cement is controlled by the addition of gypsum in a definite proportion.

vi) Cement structures have to be cooled during setting

vii) Heat of hydration during setting should be removed to avoid uneven expansion and cracking of cement structures.

viii) Water is added in the preparation of concrete to get a proper consistency.

**Generalization**

i) Different types of cement can be prepared by making slight variation in their composition, colour, etc.

**II. understanding by**

i) Identifying the different compounds of alkaline earth metals present in cement

ii) Explaining the importance of calcium compounds in the manufacture of cement

iii) Identifying the scientific processes used in the manufacture of cement

iv) Identifying the ratio and its importance among the constituents of cement

v) Analysing the different types of chemical reactions involved in manufacture of cement

vi) Classifying the different types of chemical reactions involved in the manufacture of cement.

vii) Interpreting why certain compounds and processes are used in the manufacture of cement (eg: gypsum, water, dry process etc.)

ix) Estimating the yield of cement from a definite composition of its constituents

x) Extrapolating the ideas like setting of cement, heat of hydration etc to explain other relevant situations

xi) Differentiating between structure and properties of materials and products involved in the manufacture of cement.

xii) Distinguishing between role and properties of calcium and magnesium compounds in determining the strength of cement

xiii) Identifying and controlling variables in the production of cement

xiv) Constructing and using simple devices, models, etc.

xv) Explaining how production of cement can be increased

xvi) Identifying the manipulative and productive skills involved in the manufacture of cement.

xvii) Identifying the safety measures to be observed in the manufacture of cement

xviii) Comparing the cost of production with the yield of cement.

xix) Identifying the hazards involved in cement industry

xx) Predicting the ways and means for enhancing the quality and production of cement.

**III application of knowledge gained in**

i) Explaining why cracks in buildings and bridges etc. occur

ii) Identifying ways and means for better use of cement in construction purposes.

iii) Discovering alternatives for increased production and quality in cement industry.

iv) Explaining the different types of chemical principles and reactions involved in other chemical industries.

v) Suggesting better precautionary measures that can be observed in factories and industries.

vi) Suggesting better ways and means for the disposal of waste in factories thereby reducing environment pollution

vii) Evaluating the present status of cement industry in Kerala and India

viii) Solving problems that occur in every day life

ix) Selecting a Chemistry-related occupation

**IV. Skills like**

i) Acquisitive skills – ie. listening, observing, locating sources, inquiring, investigating, gathering data, classifying, recording, setting up experiments, etc.

ii) Observation skills – i.e. comparing, contrasting, classifying, organising, outlining, reviewing, analysing, evaluating and recording

iii) Cognitive skills – i.e. recall of knowledge, providing examples, application of knowledge gained, interpreting information, analysis of data, synthesis of data, evaluating ideas of others, etc.

iv) Manipulative skills – i.e. using instruments, using proper setting, handling properly, demonstrating, describing parts and functions, experimentation, repairing and maintaining equipments, instruments etc. making simple equipments, etc.

v) Communication skills – i.e. asking questions, discussion, explanation, reporting, writing criticism, graphing, peer teaching, etc.

**V. positive Attitude towards**

i) Learning more about scientific principles and scientific processes

ii) Application of scientific principles in the field of technology and industry

iii) Establishing strong school-industry relationships

iv) The need and importance of community involvement in the field of education

v) Selecting chemistry-related vocations.

vi) Implementing and organizing small scale chemistry-related industries.

**VI Create interest in**

i) Learning more about science and technology

ii) Industry-related technology and occupations

**VII appreciation towards**

- i) The work of scientists and technicians
- ii) Dignity of labour
- iii) The roll of technology in minimising human labour

## LESSON TRANSCRIPTS FOR ATL

### Topic: Preparation and properties of Cement.

**SUBUNITS**

| | |
|---|---|
| Sub Unit I | Composition of Cement |
| Sub Unit II | Manufacture of cement |
| State(i) | grinding of raw materials using either dry process or wet process |
| Stage (ii) | Production of cement linker |
| State (iii) | Production of cement |
| Sub Unit III | Setting and hardening of cement |
| Sub Unit IV | Concrete |
| Sub Unit V | Properties of white cement |
| Sub Unit VI | Preparation of Portland cement |
| Sub Unit VII | Plaster of Paris – preparation and properties |
| Sub Unit VIII | Lime – Manufacture and properties |
| Sub Unit IX | Cement paint |
| Sub Unit X | Preparation and properties of metallic calcium |

**<u>Description of lessons</u>**

**Sub unit I**

Name: i) Cement Industry in India – particularly in Kerala

ii) Types of Cement – Composition of Cement

Std. XI No. of Students –60

**Preliminary Information**

Pupils know that cement is used for construction purposes. They may know some of the major cement industries in Kerala. They may be familiar with the raw materials used for the production of cement and they may know the uses of these materials in daily life. They may be knowing some of the chemical reactions of these materials.

**Specific Objectives**

Students will be able to develop

I Knowledge of

- i) Facts (I) & (X) in the unit plan
- ii) Concepts (i), (ii) & (iii) in the unit plan
- iii) Generalisation (i)
- iv) The major cement industries in Kerala
- v) The machines and technological gadgets used in the industries.

II Understanding by

- i) items (i), (ii), (iii) in the unit plan
- ii) identifying and comparing the different types of cement in ordinary cement or portland cement, white cement and coloured cement

iii) the way in which the different types of cement can be identified.

iv) identifying the composition of cement - cement is a mixture of calcareous and argillaceous materials and there exists or the production necessitates a fixed ratio between these materials.

III Application of Knowledge gained in

i) finding the components of different types of cement

ii) identifying the uses of different types of cement

iii) item (vii) in the unit plan.

IV Skills like

i) observation skill

ii) acquisitive skills like inquiring, searching and locating sources, investigating background information, etc.

iii) Communication skills like asking questions, discussion, explanation, writing a report of an experiment or demonstration, etc.

iv) Cognitive skills including

a) recall of knowledge and procedure

b) providing him or her own examples, perhaps by reporting his or her own observation and experience in terms of new connection made

c) application of knowledge gained in a novel situation

d) interpreting information

e) evaluating ideas of another person

v) Skills in critical thinking by distinguishing between facts and opinions, regarding the processes used in the manufacture of cement.

V Creativity through

i) Developing a plan of action for further learning

VI A positive attitude towards collaborating industry with education.

VII Value human labour and evaluate role of education in promoting it.

**Aids used**

i) Charts showing cement industries in Kerala

ii) Slides showing composition of cement

iii) Dioramas, Chemicals etc.

**LESSON PLAN FOR ATL**

**Phase I – Procedure Design Phase**

***Introduction***

In this unit, a general picture of the cement industry in India – especially in Kerala - is presented by the teacher. Pupils identify the location of cement factories in Kerala and are made familiar with the major product or type of cement manufactured in these factories.

| Sl. No | Learning Experiences | Learning outcomes |
|---|---|---|
| i) | Pupils are made familiar with the origin of cement. They recognise that it was discovered in England and was like the famous Portland rock of England and named as Portland cement | identifies the origin (k)<br><br>recognises the naming (k) |
| ii) | With the help of teacher, pupils identify the major cement industries in India, especially in Kerala | locates (a) |
| iii) | Pupils locate the two factories in Kerala, ie. one Malabar Cements at Walayar and Travancore cements in Kottayam. They recognise that two types of cement are produced in these factories ie. ordinary cement is produced in Malabar Cements and white cement is produced in Travancore Cements | recognises (k)<br><br>identifies (k)<br><br>identifies (u) |
| iv) | Pupils observe the samples of two types of cements shown to them. They identify the physical features such as colour, smell, appearance, texture, etc. They compare these features | observes (u)<br>identifies (u)<br>distinguishes (u)<br>compares (u)<br>differentiates (A) |
| v) | With the help of teacher they infer that the two types of cement slightly differ in their components and composition | infer (A) |

| | | |
|---|---|---|
| vi) | Pupils recall that cement is used for construction purposes and it forms strong structures when mixed with water | recalls (k)<br><br>states (k) |
| vii) | Pupils identify that cement is prepared from a mixture of calcareous and Argillaceous compounds. They recognise that commonly used raw materials are limestone and clay | identifies (u)<br><br>recognises (k)<br><br>identifies the sources (k) |
| viii) | With the help of teacher pupils prepare a chart showing the constituents or components present in raw materials<br><br>Calcareous materials [$CaO$]<br><br>Argillaceous materials<br><br>[$SiO_2 + Al_2O_3$) | observes (u)<br><br>recognises (k)<br><br>identifies (u)<br><br>compares (u)<br><br>infers (u) |
| ix) | Pupils identify that powdered coal or fuel oil is used for ignition and gypsum [$CaSO_4$. $2H_2O$] are the other two raw materials used | identifies (u)<br><br>recognises (k) |
| x) | Pupils observe the slide shown by the teacher indicating the ingredients and then function. The recognise the formula, composition, their structure compares their functions etc.<br><br>a) $CaO$ – principal constituent, its (50-60%) quantity is regulated | |

| | | |
|---|---|---|
| | b) $SiO_2$ – Imparts strength to cement<br>c) $Al_2O_3$ – Quick setting property<br>d) $CaSO_4$ – Retards the initial setting property<br>e) $Fe_2O_3$ – Colour, strength and hardness (1-2%) to cement<br>f) $SO_3$ – Soundness to cement<br>g) Alkalies - Small amount provides good qualities to cement | |
| xi) | Pupils analyse the relative composition of each component. They recognise that the ratio between silica to alumina lies between 4 and 2.5 while that of Calcium oxide to silica + alumina ferric oxide should be as close to 2 as possible. | identifies the relative composition (u)<br>infers (u)<br>compares (u) |
| xii) | With the help of teacher, pupils reason out why this ratio is maintained. They identify that if lime is in excess, the cement cracks during setting and if lime is less than required by the above ratio, the cement is weak in strength | reasons out (A)<br>analysis (A)<br>interprets (A) |
| xiii) | Pupils explain how different types of cement are prepared ie. it may be due to the variation in the relative proportion of ingredients | explains (u)<br>compares (u)<br>differentiates (u) |

**Phase I – Part II**

Sixty students of class XI of Catholicate H.S. school, Pathanamthitta are taken to the cement factory, Travancore Cements, Kottyam. They are informed that they are going to learn the manufacture of cement by observing the activities and procedures in the factory and practising these activities along with the workers, ie, in an apprenticeship-type mode. For that they have to observe the processes and procedures carried out in the factory, identify the skills required to perform the activities, the physical and chemical processes and changes taking place, safety measures observed, and all such relevant points. A plan of action for Apprenticeship-Type Learning is then prepared.

Students are divided into 5 groups A, B, C, D & E each group having 10 students each. Each group is assigned to work under the supervision of a member from among the staff. Each member of the group has to work independently within the group without losing group consciousness. The overall monitoring is done by the teacher. Rotation of activities within groups is done to ensure that all students complete each and every activity.

Pupils observe carefully how the manufacture of cement is carried out in the factory. They identify the things and processes used, its structure, composition, quality, etc. the basic principles of production yield of cement etc. and prepare a list of things to be observed and noted. They prepare a sketch of the process of manufacturing of cement.

**Phase II – Observation and Activity Phase**

**I - Learning Environment – Observation by Students**

***Introduction***

Pupils are familiar with the raw materials commonly used in cement industry. Pupils recognize that white cement is manufactured in the factory with the trade mark. VEMBANAD White cement. Students are then asked to make a thorough observation of the procedures going on in the factory.

| | **Learning Experiences** | **Learning outcomes** |
|---|---|---|
| 1 | Pupils observe the raw materials- colour, size, appearance, strength etc. used for the manufacture of cement | Observes (s)<br>Identifies the physical properties (u) |
| 2. | With the help of staff pupils identify the sources from which the raw materials are obtained<br>The calcareous material used is the special quality shell drudged from the sea. It is 98-99% pure $CaCO_3$ with very little amount of impurities | recognises the source (k)<br>identifies (u) |
| 3. | They recognise that instead of limestone, shell is used as the source of CaO | distinguishes (u) |

| | | |
|---|---|---|
| 4. | Pupils identify that iron content in shell is very less than that in limestone and hence shell is used for producing white cement | infers (u) |
| 5. | From this pupils infer that metallic compounds having colour can add colour to cement | infers (u)<br>interprets (u) |
| 6. | Pupils recognise the other raw materials used as white clay or China clay obtained from Thonnakkal in Trivandrum District and white sand called Cherthala sand obtained from the sea shore near Cherthala in Alappuzha district | identifies (u)<br>recognise the source (k)<br>names (k) |
| 7. | Pupils observe the physical properties of these raw materials and identify that these materials contain very little amount of colouring pigments and are hence used for manufacturing white cement | observes (s)<br>identifies (u)<br>compares (u)<br>infers (u) |
| 8. | Pupils observe and record the following things<br>Amount of raw materials used<br>Gaining of materials<br>Machine used – Rotating<br>Process used – wet process<br>Time taken to complete the process<br>nature of product | observes (s)<br>records (u)<br>compares weight (a) |

| | | |
|---|---|---|
| 9. | Pupils identify that slurry is obtained after grinding and there exists a fixed ratio of silica to alumina in this slurry | Identifies (u) |
| 10. | Pupils identify that white gypsum obtained from Thoothukkudi is added to the slurry to attain the required composition of cement, they recognise this process as blending of slurry | recognises (k)<br>names (k)<br>explain (u) |
| 11. | Pupils identify that burning of this mixture gives the product called cement clinker | Identifies (u) |
| 12. | Pupils identify the physical characteristics of cement clinker. They analyse the composition of cement clinker | Identifies (u)<br>analysis (a) |

**II - Learning through Apprenticeship**

Here pupils have very little opportunity for motor activities. They have to observe and record the activities only. They have then to deduce idea from their observation of learning environment.

By monitoring the work of students, the teacher and staff analyse this skill in observation, communication, recording of activities, etc. Pupils are asked to prepare a detailed report of their observation of the learning environment. They are encouraged and asked to clear doubts regarding their observation.

**Phase III - Reflection and Idea generating Phase**

***I – Discussion on student record of activities***

In this phase, pupils present their ideas from observation of the learning environment. They analyse their observation, critically evaluate and interpret ideas, deduce concepts, extrapolate ideas and arrive at conclusions. They develop a cognitive apprenticeship type learning by

i) reporting their observations or experiences in everyday terms

ii) picking out, restating or remembering important facts, concepts or principles that have been presented.

iii) distinguishing between given examples and non examples for the various chemical compound, chemical reactions, industrial processes, etc.

iv) providing their own examples – for the various types of processes, reactions, etc.

vi) applying the new concepts / principles (plus native wit and personal experience) to analyse interpret or plan a new situation.

Point I Pupils discuss why shell is used instead of limestone for preparing white cement. With the help of the teacher pupils identify that shell contains about 99% of $CaCO_3$ and only very little amount of Iron which is responsible for the colour of cement. From this they infer that coloured cement can be prepared by adding metals having coloured compounds, to the cement.

Point II Pupils discuss the qualities of white clay and white sand used.

They extrapolate the idea that china clay is used for the preparation of Titanium dioxide in Travancore Titanium products, Trivandrum.

Point III**:** They notice the point that raw materials are not accurately measured before mixing. So there may be some other means for estimating the composition.

Point IV They inquire why wet process is used than dry process. With the help of teacher pupils identify that dry process requires more fuel for evaporation, which makes production more expensive.

Point V Pupils discuss the nature of cement clinker obtained, i.e. physical properties and compares these to that of cement.

Point VI Pupils discuss why gypsum is added to cement clinker. i.e. to reduce the initial setting property.

Point VII Pupils are asked to express their attitude towards learning the unit in an industrial setup than in school.

Point VIII Pupils suggest the possible reactions that may take place during the preparation of cement.

Additional points, if any:

***II Rectification of errors and remediation***

During discussion and analyzing the report teacher locates errors and suggests remedial measures. Pupils then list out the concepts developed during the above phases. Teacher motivates pupils to present their own ideas, identify additional points and suggest alternative concepts.

***III Conclusion and Summary and Learning***

Pupils are asked to prepare a summary of their learning and suggest new areas of study or further use of the concept developed.

**Phase IV - Evaluation and extension**

Formative evaluation is done during learning. The reports are evaluated and the observations are consolidated in a scoring sheet.

### 4.4.5 Conclusion

A model of teaching is not a simple fixed formula for completing a job. It provides definite ideas for creating an environment from which students are likely to learn certain kinds of things, but it should be flexible, fluid instrument that can be modified to fit different types of subject matter and that responds to students who are different from one another. Thus the model is to be validated.

Through ATL, students can learn many things outside the classroom which they cannot grasp within the four walls of the classroom. It must also be remembered that students not only acquire cognitive structures of the world around them, but also the facility to add and refine these structures. Whenever teachers ask students to identify trends, compare and predict, their teaching will be effective whether or not they use models consciously.

If we are able to make improvements in learning at the HSS level using the ATL Model, contributing to a more valuable and meaningful education for the student, a more motivated and skillful student will emerge into higher education to concentrate on the more specialized subject knowledge and related skills.

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