CHAPTER – I
THEORETICAL BACKGROUND OF THE STUDY

1.1 INTRODUCTION

The terms and circumstances of human existence are changing with the advent of science. We are so accustomed to live in a world of science that we seldom stop to think about how science is constantly changing our way of life. The vast and explosive scientific and technological revolution has produced a fantastic growth of scientific knowledge in most fields of human activity. As a result, many societies are experiencing a change in the ability profile of their human resource needs. Therefore, the education system is confronted with pressure to adopt educational programmes that reflect new ways of learning.

Learning is a journey and has intrinsic merit if it moves in the right direction, thus requiring significant shifts in many aspects of teaching-learning processes. Developing the right paradigm is the most important of all. The learning paradigm is more than an incremental change in an institution's organizational procedures or priorities. Rather, it involves a holistic and system-wide change away from the instruction paradigm and the organizational structures that reflect it. Learning paradigm that frames learning holistically, recognizes that the chief agent in the process is ‘learner’ and he/she constructs knowledge out of his/her own experiences. Learning has to be organized in such a way that learners can learn how to become architects of their own learning processes (UNESCO, 2003). In some instances, a newly constructed idea fits easily into the structure of existing understanding. In other cases, the construction of new understanding catalyzes substantial revision of existing knowledge into a new and more coherent framework.

Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others. Understanding science requires integration of a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict natural phenomena, and ways to apply these ideas to many events.
The construction of deep scientific knowledge results from actively practicing science in a structured learning environment and therefore it is essential to consider science as a process of constructing knowledge. To encourage independent learning in science, the inquiry aspect of science should be related to the structure of scientific knowledge and the investigative strategies of science. The very nature of science is such that a wide variety of learning experiences can be provided for learners to help them explore the world. Effective science education adds to the child’s store of knowledge about himself, his environment and his world (Victor & Marjorie, 1967). This will help the learner to acquire insight into the structure of science and to live successfully in an ever-dynamic world. Therefore, teaching-learning process in science has to be designed and structured in such a way that it helps learners recognize conflicts and inconsistencies in their own thinking. The challenge faced by science teachers is to provide wide varieties of learning activities and experiences which are consistent with the nature of science and perceive science as a process of exploring and active construction of knowledge.

1.1.1 Information and Communication Technology in Learning

Recent developments in the field of Information and Communication Technology (ICT) are revolutionary in nature. The ability to use ICT effectively and appropriately is essential to allow learners to acquire and exploit information within every sphere of human activity. ICT is not an initiative introduced purposefully into an existing system in order to bring about improvement, but a major perturbation that has established the existing order and led to a large number of unpredictable changes (Somekh, 2007). The creative potential of ICT can be unleashed when we actively make use of it.

With its enormous potential, ICT has undoubtedly opened new avenues for lifelong learning which helps people to compete better in the new information economy. Knowledge society has enabled a shift away from technology as a driver of change to a tool that offers new ways of combining widespread information. ICT facilitates the enculturation processes of lifelong learning (Mann, Shakeshaft, Becker & Kottkamp, 1999). Remarkable growth in ICT has led to an increasing need for education that is effective, efficient and satisfies the demands for greater sophistication and diversification of educational content. ICT aims to empower teachers and learners and tries to transform teaching-learning processes from being highly teacher dominated to
student centered. This transformation may result in increased learning gains for students, creates opportunities for learners to develop their creativity, problem solving abilities, communication skills and other higher order thinking skills. A meta analysis that examined the impact of technology on student learning revealed an increased teacher-student interaction, cooperative learning and most importantly, problem solving and inquiry (Statham & Torell, 1996). Therefore students should be oriented to this possibility allowing them to stand their ground amidst the technology mediated onslaughts of the modern world.

We are in an era in which we have ubiquitous electronic interactivity and have a tremendous range of educational resources available. Today’s high school students often have the maturity and technical expertise necessary to participate in e-learning experiences. Moreover, the demands of information era can’t be satisfied with classroom instruction as the only source of learning. The styles of teaching and learning should go far beyond traditional pedagogic efforts within the four walls of classroom, and in this context, ICT has paved the way for accelerating the paradigm shift by providing more flexible ways of learning and offers learners more ways to search for the most effective and efficient path to learning. The ready availability of computer technologies in the classroom and in the community has greatly expanded the educational options available to learners.

1.1.2 Information and Communication Technology in Science Learning

Information and Communication Technology has an important role to play in science learning. In recent years, there has been a shift from the use of science as a vehicle through which students learn and use ICT skills, towards the use of ICT skills as tools to assist learning in science. There has also been growing interest in providing differentiated instruction to individual students by tapping the wide potentialities of ICT. Research suggests that ICT can be used to strengthen procedural knowledge and that the main forms of ICT, which are relevant to school science activity, include: multimedia software, information systems, publishing and presentation tools and computer projection technology (Osborne & Hennessy, 2003). ICT could reduce both the time and resource constraints in practical work. Newton and Rogers (2003) suggest that the intrinsic properties of ICT helps for time saving or handling data, and there are potential learning benefits from the manner in which ICT is used in the science classroom.
ICT can provide access to wide range of resources that are of high quality and are relevant to scientific learning. In some cases the resources fill gaps where there are no good conventional alternatives; in other cases they complement existing resources. The multi-media resources available enable visualization and manipulation of complex models, three-dimensional images and movement to enhance understanding of scientific ideas. ICT widens the range of material that can be used in teaching and learning to include text, still and moving images and sound, and increases the variety of ways that the material can be used for whole class and individual learning. (Eggert, Meyvant & Allyson, 2008) This means that a teacher can go some way in meeting the needs of students with different learning styles.

ICT can improve the quality of data available to students. Information learned from the internet can be more up to date, and data obtained include more frequent and more accurate experimental readings. Computers also allow repetitive tasks to be carried out quickly and accurately so that student can spend more time on thinking and analyzing the scientific data that has been generated. Osborne and Hennessy (2003) suggests that as the science curriculum moves towards a greater emphasis on scientific reasoning and analytical skills, there will be more opportunities for ICT to play a key role in science education.

In our increasingly complex technological world, understanding of science and higher order thinking that goes along with it can’t be left solely to small scientific elite. Therefore, science teachers should strive to completely utilize the potentials of ICT to maximize science learning among all the learners. ICT should be placed at the heart of the learning process basing science experiences within a social context rather than as an additional peripheral experience. Hence technology should be used not only as a focus for teaching but also as a starting point from which to develop scientific concepts. Activity started in one classroom, can be continued using the potential of ICT. But the challenge is to blend face-to-face instruction and the advent of ICT effectively. It is essential that ICT should be used in alignment with existing pedagogical practice or the pedagogy should be restructured or evolved to incorporate the benefits of using ICT in learning.

Learning using ICT tools, especially online learning, is gaining its popularity in K-12 education because of its unique abilities to provide rich student-teacher-peer interaction, to provide students with enriched learning experiences, to extend learning beyond the school day, and to support more successful differentiated learning.
strategies that personalize students’ educational experiences. At the same time, in an
age when information and communications technology skills are so critical, and so
much collaboration, resource sharing, content development and learning can be done
digitally and asynchronously; it is unlikely that student learning will continue to be
based solely on printed textbooks and face-to-face classes. This evolution attempts to
provide enriched content, extend learning beyond school walls and the confines of
school day, and has spurred the creation of programmes which blend online learning
and face-to-face instruction.

1.2 BLENDED LEARNING

Like many advances in educational practices, blended learning is defined and
implemented in multiple ways. Blended learning is a hybrid of online learning and
Face-to-Face (F2F) instruction using a variety of learning resources. Blended learning
is a flexible learning strategy that integrates innovative and technological advances of
online learning with interaction and participation of traditional classroom learning.
Thorn (2003) describes blended learning as a way of meeting the challenges of
tailoring learning and development to the needs of individuals by integrating the
innovative and technological advances offered with the best of traditional learning.

North American Council for Online Learning [NACOL], an International
Association for K-12 Online Learning, defines blended learning as combining online
delivery of educational content with the best features of classroom interaction and live
instruction to personalize learning, allow thoughtful reflection, and differentiate
instruction from student-to-student across a diverse group of learners. Carter (as cited
in Battye & Carter, 2009) defines blended learning as a strategic and considered
approach to teaching and learning that effectively integrates different models of
teaching and styles of learning whereby both face-to-face and online learning are each
made better by the presence of the other.

Ultimately, the exact definition of blended learning, beyond some combination
of online and face-to-face learning may not matter. Kim (2007) has classified learning
into three key dimensions: physical class based versus virtual, formal versus informal,
and scheduled versus self-paced. There are several possible combinations that can be
formulated out of these three dimensions. He has defined blended learning as a
combination of two or more of all possible learning types. He has given one important
qualifier to this definition. At least one of the learning types must be a physical class-
based type and at least one other learning type must be online learning type. This is to make sure blended learning remains a combination of some form of traditional learning and some form of online learning.

Along these lines, Dziuban, Hartman and Moskal (2004) in a research brief noted that blended learning should be viewed as a pedagogical approach that combines the effectiveness and socialization opportunities of the classroom with the technologically enhanced active learning possibilities of the online environment, rather than a ratio of delivery modalities. In other words, blended learning should be approached not merely as a temporal construct, but rather as a fundamental redesign of the instructional model with a shift from ‘lecture’ to ‘student-centered instruction’ in which students become active and interactive learners. This enables increased interaction between student-instructor, student-student, student-content, and student-outside resources.

Blended learning reflects more conscious and intentional approach in designing optimal instruction or learning environments following the strategy of blending components while the blended character of traditional instructional contexts is largely the result of habit (tradition), convenience or happenstance (Rossett & Frazee, 2006). A superficial understanding of blended learning is that it simply adds non face-to-face elements into the traditional course structure. But this most often results in a dysfunctional phenomenon known as the “course-and-a-half” (Edudcause, 2010). Schools may be particularly susceptible to this trap if the added online elements are simply based on the latest technology, which can give a false impression of true innovation.

As both the face-to-face instruction and online learning suffer from limitations, it is natural to combine the strengths of the two modes into blended learning. Combining face-to-face and fully online components optimizes both environments in ways impossible in other formats (Dziuban & Hartman, 2004). Garrison and Vaughan (2008) defines blended learning as a new educational paradigm that integrates the strengths of face-to-face and online learning — a design approach whereby both face-to-face and online learning are each made better by the presence of the other. He asserted that blended learning is not an addition that simply builds another expensive educational layer. Instead, it represents a restructuring of the class contact hours with the goal of enhancing engagement and extending access to internet-based learning opportunities. Most importantly, blended learning is a
fundamental redesign that transforms the structure of, and approach to, teaching and learning.

The key assumptions of a blended learning design given by Garrison and Vaughan (2008) are:

- Thoughtfully integrating face-to-face and online learning
- Fundamentally rethinking the design to optimize student engagement
- Restructuring and replacing traditional class contact hours.

Blended learning is an educational formation that integrates online learning techniques including online delivery of materials through web pages, discussion boards and/or email with traditional teaching method. The pedagogy of blended learning is based on the assumption that there are inherent benefits in face-to-face interaction as well as the understanding that there are advantages in using online methods (Clark & Patrick, 2007). Blended learning is used to describe learning that mixes various event based activities, including face-to-face classrooms, live e-learning, and self-paced learning (Valiathan, 2002).

Providing several online options in addition to traditional classroom training actually increased what students learned. (Dean, Stahl, Sylvester & Pearson, 2001; Graham & Allen, 2005). Blended Learning, the teaching practice that combines teaching methods from both face-to-face and online learning, is an established, rapidly growing instructional model that is proving highly effective in helping schools and districts address the challenges of student achievement, limited resources, and the expectations of 21st century learners (Eduviews, 2009).

1.2.1 Ingredients of Blended Learning

Five ingredients of blended learning proposed by Carman (2005) are:

- Live events
- Self paced learning
- Collaboration
- Assessment
- Performance Support
**Live events**

Synchronous, teacher led learning environments in which all learners participate at the same time. For many learners, nothing can replace the ability to tap the expertise of a live teacher.

**Self-paced learning**

Learning experiences that the learner completes individually at his/her own pace and time such as recorded live events, Internet or CD-ROM based learning; it implies on-demand learning at a pace that is managed or controlled by the learner.

**Collaboration**

It implies more dynamic communication among learners that brings about knowledge sharing. Collaborative learning has more advantages which are not available from traditional instruction because a group can accomplish meaningful learning and solve problems better than any individual alone can. It can be extended from discussion in the live classroom to synchronous communications in chat room or in open discussion forums and asynchronous communication by using e-mail and threaded discussion.

**Assessment**

It is both live and online measure of learner’s knowledge to determine prior knowledge as well as to measure learning transfer.

**Performance Support**

These are the reference materials that enhance learning, retention and transfer. It may be printed references, downloaded multimedia learning objects, documentation etc. The ingredients of blended learning are pictured below:

**Figure 1.1: Ingredients of Blended Learning**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Performance Support</th>
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<tbody>
<tr>
<td>Self-Paced Learning</td>
<td>Live Event</td>
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<tr>
<td>Collaboration</td>
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1.2.2 Models of Blended Learning

Blended learning can be implemented using a wide range of models. Eduviews (2009) summarizes the continuum of models that can be used in schools as:

- **Model 1**: Fully online curriculum with options for face-to-face instruction
- **Model 2**: Mostly or fully online curriculum with some time required in either the classroom or computer lab
- **Model 3**: Mostly or fully online curriculum with students meeting daily in the classroom or computer lab
- **Model 4**: Classroom instruction with substantial required online components that extend beyond the classroom and/or the school day
- **Model 5**: Classroom instruction that includes online resources with limited or no requirements for students to be online

*Figure 1.2: Models of Blended Learning*

These models give a working picture of the many ways in which online learning blends with and supports traditional instruction. It may not be plausible to launch a blended learning program by replacing most of the face-to-face instruction by online learning as depicted in Model 1 (Eduviews, 2009). However the strategy is flexible enough to be adapted to any model which fits the current resources and requirements of the institution.
1.2.3 Blended Learning as a Pedagogical Strategy

In a very simple way, blended learning can be considered as the integration of online learning and classroom learning. There is an urgent need to consider issues such as those related to time distribution as well as classroom activities, the relationship between resources and different learning modes, the balancing of online learning and classroom learning and the role of teachers in a blended learning environment. Various theories of learning and instruction contributed to the rise of blended learning strategy. Researches on blended learning explored how the pedagogical assumptions of blended learning evolved from various conceptual understandings of learning and instruction. Some of the pedagogical assumptions of blended learning are:

- High priority attached to student learning and to pedagogical needs while considering and applying blended learning approaches
- Strategic and systematic use of technology in association with quality face-to-face environment to support student learning
- Enhancement and ultimate transformation of existing learning and teaching processes
- Accommodation of diversity in student learning experiences
- Enhanced interaction among students, teachers, peers and the community
- Increased capacity for student-managed learning
- Learners learn how to become architects of their own learning processes
- Learning that takes place at students’ discretion in terms of time and place
- Learning takes place in multiple contexts to support flexible knowledge transfer
- Teacher acts as a facilitator rather than a knowledge transmitter.

With the growth of blended learning, pedagogy of blended learning also is evolving. As mentioned, role of a teacher is getting transformed from ‘lecturer’ to ‘mentor’ who gives continuous support, guidance and assistance. The blended learning models are so flexible and adaptive that teachers can create instructional activities that give students the opportunities to work collaboratively, tapping their interests and abilities in social learning (Eduviews, 2009).

A good merit of blended learning is that it can cater to individual preferences of learning style. Students are free to choose their preferred learning style to some
extent though some components may be compulsory (Harding, Kaczynski & Wood, 2005). Thus differentiated instruction is possible to a large extent. Self-pacing allows for the engagement of every learner at any given time in blended learning. Students also visualize that the learning involved becomes a process, not isolated individual learning tasks.

One of the most specific advantages is the opportunity to quickly establish a sense of community amongst student learners (Garrison & Kanuka, 2004). Within the blended learning classroom, students meet during face-to-face instruction, and then have opportunities to collaborate, communicate with open dialogue, experience critical debate through a world wide open platform which in-turn facilitates greater reflection on the part of learners. Blended learning approach provides room for the development of autonomy, self-efficacy and individual organizational skill since it gives scope for self regulated learning. This, in effect, contributes to the development of higher order thinking.

1.3 HIGHER ORDER THINKING

A fundamental characteristic of the world students now enter is ever-accelerating change; a world in which information is multiplying even as it is swiftly becoming obsolete and out of date; a world in which ideas are continually restructured and retested. Irfaner (2002) (as cited in Dayioglu, 2003) observed that people are exposed to various kinds of information from various kinds of sources and if the information is not elaborated with analysis or evaluation, it is highly likely for people to be confused with all this information and even to be exposed to brainwashing.

Engaging students sufficiently in the subject matter to stimulate higher-order thinking is a challenge in many teaching situations. Unfortunately, most of our instruction intends only to develop lower order thinking or to impart surface knowledge and neglects the significance of critical thinking and problem solving skills as essential to effective learning and productive living.

Higher order thinking is thinking on a higher level rather than memorizing facts or telling something back to someone exactly the same way it was told. When a person memorizes and gives back the information without having to think about it, we call it as ‘rote memory’. Higher order thinking takes thinking to higher levels than just restating the facts. It requires that we do something with the facts. We must understand them, connect them to each other, categorize them, manipulate them, put
them together in new or novel ways, and apply them as we seek new solutions to new problems. Problems need to be worked through systematically and logically in order for learners to come to a satisfactory conclusion.

A study conducted by Raths, Jonas, Rothstein and Wassermann in 1967 (as cited in Carr, 1990) asserted that higher-order thinking can be a part of our curriculum, but it requires moving beyond the traditional lecture and exam mode to encourage it. Thinking cannot be divorced from content; in fact, thinking is a way of learning content. In every course, and especially in content subjects, students should be taught to think logically, analyze and compare, question and evaluate. Skills taught in isolation do little more than prepare students for tests of isolated skills (Spache & Spache, 1986).

When students really ponder a question, discuss it in groups, or explain their answers to others, they are more likely to use skills at more advanced levels of thinking. Having the opportunity to pause, reflect, analyze, and discuss processes and concepts is the real key. Active-learning methods, such as cooperative in-class activities, and on-line quizzes or homework with rapid evaluation and feedback, help to promote higher-level reasoning (Yuretich, Khan, Leckie & Clement, 2001).

Higher order thinking skills should be developed in our students to enable them to feel responsible for their own learning which will help them to become authentic science learners. Scientific teaching demands active learning strategies to engage students in the process of science and to develop their scientific reasoning. Not surprisingly, due to the nature of science, excellence in science teaching focuses on the development of students’ critical thinking skills and problem solving ability. Though thinking critically utilizes higher-order thinking, critical thinking and higher-order thinking are not one and the same. Critical thinking is one of the members of a family of closely related forms of higher-order thinking which include problem solving, creative thinking, and decision-making (Facione, 1990).

1.3.1 Critical Thinking

In our everyday life, we are faced with decisions that require reasoning, understanding, interpretation, analysis, explanation and synthesis. Despite the importance society puts on critical thinking, researches showed that many of our students are not good in critical thinking. Unfortunately, many of our students have poorly developed critical thinking skills (Rudd, Baker & Hoover, 2000). Critical
thinking is the process of analyzing and evaluating thinking with the idea of improving it and taking it to a higher level.

Critical thinking is a mode of thinking about any subject, content or problem in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them (Cascini & Rich, 2007). Good thinking skills will not be developed on their own, they must be taught (Beyer, 1987).

A study conducted by Raths, Jonas, Rothstein and Wassermann in 1967 (as cited in Carr, 1990) and the study conducted by Ennis (1990) suggest that the development of these skills is best done in association with specific content or within domain of knowledge. Therefore the teaching of critical thinking should be integrated into in all courses and in all classroom areas - lectures, discussions, homework and writing assignments (Bowers, 2006). Bransford, Vye, Kinzer and Risko (1990) suggested that one way to help students develop critical thinking skills is to focus on problems or cases where they are challenged to deal with real data and experiences. Therefore teachers would benefit the most by having access to discipline specific learning activities that they can seamlessly integrate into their courses.

1.3.1.1 Definitions of Critical Thinking

Different people define critical thinking in different ways, depending on their respective academic disciplines, points of view etc. We can trace the origins of critical thinking back to the early Greek philosophers like Socrates. The word itself comes from 2 Greek words, kriticos, meaning discerning judgment and kriterion, meaning standard. Paul (1995) defines critical thinking as thinking that displays mastery of intellectual skills and abilities, and disciplined, self-directed thinking that exemplifies the perfections of thinking appropriate to a specific mode or domain of thinking.

Paul (1995) further refined critical thinking by identifying three thought traits and/or processes possessed by a critical thinker. They are: elements of reasoning, traits of reasoning, and reasoning standards. Crunkilton (1996) (as cited in Rudd & Baker, 2009) presented a pragmatic approach in promoting critical thinking in students by specifying conditions necessary for thinking. The first condition is having something to think about such as a person, an object, a situation, problem or process. The second condition is having something to think with, such as background knowledge and resources (maps, charts, notes and computers). The third condition is
having ways in which to think. In other words, students need thinking structures to
guide their thinking process. The final condition is a reason to think. Reasons to think
vary from thinking to resolve a controversy, to solve a problem, or completing an
assigned task.

In Watson Glaser Critical Thinking Appraisal [WGCTA], critical thinking is
defined as a composite of attitudes, knowledge and skills. As per WGCTA, critical
thinking is an attitude of inquiry that involves an ability to recognize the existence of
problems, knowledge of the nature of valid inferences, abstractions and
generalizations in which the weight or accuracy of different kinds of evidences are
logically determined and skills in employing and applying the above attitudes and
knowledge. Critical thinking is the disciplined mental activity of evaluating
arguments or propositions and making judgments that can guide the development of
beliefs and taking action (Huitt, 1998). Huitt (1998) argues that critical thinking is the
disciplined mental activity of evaluating arguments or propositions and making
judgments that can guide the development of beliefs and taking action. Some other
definitions of critical thinking are: the formation of logical inferences (Simon &
Kaplan, 1989), developing careful and logical reasoning (Stahl & Stahl, 1991) and
deciding what action to take or what to believe through reasonable reflective thinking
(Ennis, 1991). Moore and Parker (as cited in Burris & Garton, 2006) define critical
thinking as purposeful determination of whether to accept, reject, or suspend
judgment.

Burden and Byrd (1994) categorizes critical thinking as a higher-order
thinking activity that requires a set of cognitive skills. Having different definitions
and meanings for critical thinking, a group of leading researchers with expertise in the
field were asked to define critical thinking through a Delphi study to achieve some
clarity in the definition of critical thinking (Facione, 1990). The experts envisaged
critical thinking as purposeful, self-regulatory judgment that results in interpretation,
analysis, evaluation, and inference, as well as explanation of the evidential,
conceptual, methodological, criteriological, or contextual considerations upon which
that judgment is based. They hypothesized that there are a set of intellectual virtues
or habits of mind that reflect one’s dispositions to think critically. The cognitive skills
listed in the Delphi report as core to critical thinking are analysis, interpretation,
inference, explanation, evaluation and self-regulation.
1.3.1.2 Developing Critical Thinking through Science Education

Science is more than a detailed organization of minute facts and complicated theories. It also includes a vast array of inter-related factual information, concepts and theories which provide us with one particular way of understanding the world and ourselves. A critical approach to teaching science recognizes that science teaching should not over-emphasize narrow mastery of conventional explanations and techniques of established science. Science teaching should be structured in such a way that it can provide flexibility and opportunities to develop deeper and more accurate thinking among students. Students should be allowed to think about their own thinking in order to make their thinking clearer and more accurate. Scientific teaching demands active learning strategies to engage students in the process of science and to develop their scientific reasoning.

Critical thinking can be best taught through an experiential learning process. This approach rests upon experiential and constructivist learning models and encourages instructors to fully engage students in the learning process (Otten & Leszczynski, 2006). Not surprisingly, excellence in science teaching focuses on development of students’ critical thinking skills. Therefore science teaching learning environment has to be structured/restructured in such a way to provide experiential learning experiences to learners so that critical thinking can be developed among learners.

1.3.2 Problem Solving

The overarching aim of science education is not to steer all students towards a career in science, but to create a populace of knowledgeable students about scientific ideas, modes of thinking, and scientific practices so that they can make informed decision about science and technology issues of global interest. Harlen (2010) conceives the goals of science education not in terms of the knowledge of facts and theories but a progression towards key ideas which together enable understanding of events and phenomena of relevance to students’ lives. One of the enduring problems that educators in the field of science face in designing science units is how to ensure a well-structured knowledge base without overburdening students with facts, formulae and inert knowledge and how to enable learners to solve problems effectively and efficiently. Chalmers and Fuller (1996) observe that students do not always apply strategies they have learnt to other contexts, because they are unaware that they are
relevant to the task. It may be that even when they recognize that a particular strategy is relevant, they do not know how to apply it.

Over emphasis on rote learnt content and terminology still characterizes much of our science teaching at secondary level. If teachers hold transmission approaches in their teaching with a focus on content coverage, students are forced to adopt surface learning approaches. To avoid this, learners need to be given opportunities to develop understanding of concepts and process skills, and be given ample opportunity to practice them in the context of the subject matter domains where they will have to use them.

Much criticism has been voiced about the lack of systematic attention paid to problem solving in the domain of science teaching. Hobden (1998) reminds us that from the first days of science instruction, sets of routine problem tasks assigned by the teacher have to be part of classroom life. In a similar vein, it has been observed by Osborne (1990) that it appears as though nearly all physical science education seems to be based on the optimistic assumption that success with numerical problems breeds an implicit conceptual understanding of science. Students seem to have great difficulty approaching problems, however, they also seem to enjoy the challenge and perform reasonably well if given proper guidance.

1.3.2.1 Definitions and Dimensions of Problem Solving

Problem solving is an interesting area of research from the past and has been defined in multiple ways. Gagne (1977) defined problem solving as a thinking process by which the learner discovers a combination of previously learned rules that he can apply to solve a novel problem whereas Pizzini, Shepardson and Abell (1989) conceived problem solving as a method of learning as well as an outcome of learning.

Dewey (1933) stated that a problem is anything that gives rise to doubt and uncertainty. He suggested a five step process for problem solving-awareness of a problem, collection of facts, data needed to solve it, formulation of hypothesis, evaluation of these hypotheses against the facts collected and verification or actually trying out a solution which seems valid.

Anderson et al. (1970) describes problem solving as personal and as an experience involving individual thinking. The steps of problem solving given are recognition of problem, refining and defining problem, examination of various
components of the system, proposal and testing of hypotheses, collection of data and offering of solution. Einstein (as cited in Grewal, 1988) considered that the formulation of a problem is more important than its solution, which may be merely a matter of mathematical or experimental skill.

Polya (1957) systematized the efficient problem solving process in four stages: understanding the problem, devising a plan, carrying out the plan and looking back. Shibata (1998) listed fourteen thinking patterns and suggested that problem solvers should choose appropriate patterns for responding to situations and categorized these fourteen patterns into three more general groups such as thinking patterns for judgments, thinking patterns for thinking processes and thinking patterns for efficient thinking. Duncker (1945) attempted to study the stages of problem solving and suggested that the stages are functional solution or value, reformulating or re-centering, suggestions from above and suggestions from below.

Newell and Simon (1972) infer several characteristics about the problem solver’s behavior. First, the behavior will be segmented and under the control of a problem solving method. Second, each method will be ordered within itself; but there will be discontinuities as activity shifts from one method to another. Since a goal may be attached by sequence of methods, a single segment of behaviour addressed entirely to a single goal may encompass several divergent sequences of behavior. They suggest that problem solving is interactive in nature, that is, it consists of repeated loops around a circuit: select a goal, select a method, evaluate the results, select another goal, and so forth.

1.3.2.2 Developing Problem Solving through Science Education

The goal of every teacher is to develop students’ understanding of the content being taught in the class, as well as to assist them in their development to become independent and thoughtful problem solvers (Bransford, Brown, & Cocking, 2000). Identifying the best means by which to accomplish this goal has been the aspiration of educational researchers for many years. Many researchers indicate that the use of problem solving instructional models and techniques to teach science influences the problem solving skill of students. Problem solving skills are promoted by providing an environment rich in potential for exploration and by encouraging students to reflect on their actions (Hass & Parkay, 1993). Reid and Yang (2002) found that inappropriate chemical knowledge prevents students’ problem solving ability in
chemistry and students become unsuccessful problem solvers if chemistry instruction does not provide them with an adequate set of rules to follow or do not help them to understand chemical knowledge during the learning process. Since problem solving ability is itself transferable, at least within a given subject matter field, facility gained in independently formulating and applying one generalization is transferable to other problem areas in the same discipline (Ausubel, 1969). He again says that aptitude in problem solving involves a much different pattern of abilities than those required for understanding, and retaining abstract ideas. He asserted that the ability to solve problems calls for qualities such as flexibility, resourcefulness, improvising skills, originality, problem sensitivity and venturesomeness. Although appropriate pedagogic procedures can improve problem solving ability, relatively few good problem solvers can be trained in comparison with the number of persons who can acquire a meaningful grasp of various subject matter fields.

Recent research has identified a prescriptive model of problem solving, although there is less agreement as to which techniques are appropriate. Attention must be paid to both the problem solving process and the specific techniques associated with important personal characteristics. That is, individuals and organizations must have a problem solving process as well as specific techniques congruent with individual styles if they are to capitalize on these areas of current research. Bilgin and Karakirik (2005) suggests Mole Solver (MS), a computer based problem solving environment that facilitates, monitors and improves the students' problems solving skills on ‘mole concept’. A computer simulation is a powerful tool to enhance learning by providing opportunities for learners to develop skills in problem identification, seeking, organizing, analyzing, evaluating and communicating information (Akpan, 2001). Efforts are required from science teachers to enhance problem solving among children in addition to content enrichment. Science teaching should provide students with opportunity to ponder and explore problems and hence their capacity to solve problem in turn gets elevated. More researches in science education are required to identify innovative strategies which promote problem solving among students.
1.4 LEARNING SCIENCE

Learning Science is never only about learning to know the natural world. In conjunction with the proposed definition that learning in general is a measurable change of behaviour, a further distinction between how one learns and what one learns is useful. It is of value to consider the processes of science as well as the product of science. Science education should be aimed at preparing students for both types of learning. The child should gain not only knowledge of the content of science but also sophistication in his use of the logical skills by which this content is accumulated. In effect, the child must learn ‘how’ to learn along with acquisition of facts and concepts in science.

In the past, possibly to a lesser extent today, subject content dominated more than the processes of science. Teaching was viewed mainly in terms of the scientific facts, concepts, generalizations, theories etc. to the exclusion of how learners learn. The shift in emphasis from science as body of knowledge to be mastered to science as a process revolutionized the idea of how students learn science. As well as becoming scientifically literate, today’s students must be equipped with the skills that enable them to observe keenly, successfully communicate, reflect objectively and analyse logically. The process of learning science helps in developing these skills along with their understanding of subject content. If science teaching is really the transmission of a body of consensually accepted knowledge, the pedagogical danger is that teaching becomes an arid business of rote learning of standard facts, theories and methods (Sears & Sorensen, 2000). The focus may also be given to the processes through which science uncovers facts and develops models.

1.4.1 Science Process Skills

Product and Process aspects of science are interdependent and complementary to each other. Both factual and conceptual approaches to science teaching emphasize the ‘product of science’. Process aspects of science include the ways in which the products were formulated. Science learning and the development of science process skills are integrated activities. Science process skills have profound influence on students in learning and in utilizing science to the optimum level in academic career (Rao & Nagakumari, 2008).
While the process skills are viewed as central to elementary school science education and important enough to be taught in their own right, they are often combined with science content, enabling children to learn both science processes and content at the same time—in a seamless learning experience. The knowledge of the product is useful in understanding the process of science and for concretizing the process for pedagogical use (NCERT, 1982). Inquiry as a basis for curriculum development is advocated by National Science Teachers’ Association. NSTA conference of scientists – *Theory into Action* (as cited in Anderson et al, 1970) presented a formulation of the major items in the processes of science and proposed that these items permeate and thread through all of a K-12 science curriculum. The major items in the processes of science given by NSTA are:

1. Science proceeds on the assumption, based on centuries of experiences, that the Universe is not capricious.
2. Scientific knowledge is based on observation of samples of matter that are accessible to public investigation in contrast to purely private inspection.
3. Science proceeds in a piece meal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sections or aspects of nature.
4. Science is not, and probably will never be a finished enterprise and there remains much more to be discovered about how things in the Universe behave and how they are interrelated.
5. Measurement is one of the important features of most branches of modern science because the formulation as well as the establishment of laws is facilitated through the development of quantitative distinctions.

The curriculum project, Science-A Process Approach [SAPA] by commission on Science Education by American Association for Advancement of Science [AAAS] in the early 1960s rejected the idea that science is only a collection of facts and de-emphasized content and focused on the process of knowing. They defined process skills as a set of broadly transferable abilities appropriate to many science disciplines and reflective of true behaviour of scientists. These skills are best thought of as a set of intellectual skills that are essential for acquiring reliable information about nature.

The major goal of SAPA is to develop a learner’s skill in using these skills or processes of science. They classified science process skills as basic science process skills-observing, classifying, measuring, communicating, inferring, predicting, using
space/time relationships and using numbers and integrated science process skills—formulating hypotheses, controlling variables, interpreting data, defining operationally and experimenting.

A symposium on science teaching organized by All India Science Teacher Education (1973) (as cited in Rao & Nagakumari, 2008) gave process oriented conceptual goals as one of the main objectives of teaching science in Indian schools. National Council of Educational Research and Training (1982) came out with a document on integrated science curriculum and emphasized the importance of science process skills by indicating that a set of unique procedures are common to all the disciplines of science which do not change with time and students should practice these skills daily in their regular classroom.

Despite the apparent failure of much of contemporary science teaching to impart science process skills to students, there is evidence that the appropriate kind of instruction can be successful. Roth and Roychoudhury (1993) (as cited in Foulds & Rowe, 1996) found that students develop higher-order process skills through non-traditional laboratory experiences that provided the students with freedom to perform experiments of personal relevance in authentic contexts. Along the same line, Sridevi (2008) found that constructivist approach was effective in improving science process skills of students. Therefore, it is necessary to provide students with opportunities to explore nature through which science process skills can be developed. The curriculum should engage the learner in acquiring the methods and processes that lead to the generation and validation of scientific knowledge and nurture the natural curiosity and creativity of the child in science (NCERT, 2005).

1.5 NEED AND SIGNIFICANCE OF THE STUDY

Organization of learning process has been characterized from the past as predominantly ‘teacher controlled’. If education is to provide an adequate preparation for the ‘information society’, schools should empower learners to become more active and responsible so that they can acquire productive skills and higher order thinking skills. Paradigm shift of learning ensures the focus of learning towards knowledge construction rather than rote memorizing some facts. Therefore more emphasis should be given to those modes of learning where self-regulation and authentic learning are possible.
Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world. This is possible only when learners are allowed to think critically, reflect and analyse their own learning process. Then, students will be able to solve problems effectively and thus can ensure maximised learning. Higher-order thinking requires students to manipulate information and ideas in ways that transform their meaning and implications. This transformation occurs when students combine facts and ideas in order to synthesise, generalise, explain, hypothesise or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allows students to solve problems and discover new meanings and understandings. Research into problem solving has indicated that one needs considerable domain-specific knowledge and skills to pose, represent, and solve problems within that domain.

Critical thinking, one of the important higher order thinking skills is a pervasive and self-rectifying human phenomenon, which constitutes interpretation, analysis, evaluation and inference. Science education looks for innovative strategies to develop these higher order-thinking skills and to make learning science meaningful. Acquiring higher order thinking skills has been widely recognized as one of the main objectives of science learning and efforts are required to improve critical thinking of students by providing meaningful learning experiences.

The old pedagogy was criticized for presenting content in lecture format to be memorized. Our school pedagogic practices, learning tasks and the texts we create for learners tend to focus on receptive feature of children (NCERT, 2005). Much teaching is still conducted on this basis, while insufficient attention is paid to learning strategies (UNESCO, 2003). Only a very few percentage of bright/gifted students who are capable of building their own learning strategies learn best and vast majority of other students are typically pushed aside and labeled weak, poor, etc. The new focus is on the process of learning and providing environments and tools that encourage everyone to become successful and responsible learners.

In moving away from a deficit model of curriculum and towards independent learning, Information and Communication Technology [ICT] has to play a very important role. Various Researches revealed that computer technology can support learning and is especially useful in developing the higher order skills such as critical thinking by engaging students in authentic, complex tasks within collaborative contexts. There is a growing shift all over the world, from the use of technology as a
delivery devise for school children to use of technology as a tool for exploration of knowledge and self-learning. A major pedagogic contribution of ICT is that it facilitates an alternate way of approaching differentiation. It becomes possible to define differentiation by learner choice, a process that is both dynamic and iterative.

National Curriculum Framework-2005 brought out by National Council of Educational Research and Training envisages that providing children more direct access to ICT and allowing them to mix and make their own productions and to present their own experiences could provide them with new opportunities to explore their own creative imagination. National Focus group on Education Technology (NCERT, 2005) pointed that even though most software tools allow an ordinary user to concentrate on the tasks at hand, it is not normally possible to respond to the different demands of the user. In this context, there is a greater need for optimizing learning paths for learners with different learning styles, exploring the maximum potential of ICT.

ICT can provide access to wide range of resources that are of high quality and are relevant to scientific learning. However in some cases ICT resources are less good than conventional ones and do not add learning (University of York Science Education, 2005). There are several researches which suggest online learning to be included as part of the traditional courses since it is found that online learning helps in improving learning, higher order thinking skills and learners’ motivation (Dabbagh & Kitsantas, 2005; Wingard, 2004; Fox, MacKeogh & Kay, 2003). But science as a discipline demands certain kinds of learning experiences such as experimentation, demonstration and all the topics cannot be transacted through online learning platforms. Therefore the issue that arises here is not about the learning resources or the mode of transfer but the proper blend of these resources; both online and traditional learning resources. Therefore, blended learning as a strategy for facilitating learning by rightly combining various components of traditional classroom learning to technology enhanced online learning is of paramount significance.

Researches indicate the benefits of blending online learning with face-to-face instruction. Clark and Patrick (2005) conducted a study on blended learning in delivering science courses and they found that students supported blended learning and it is possible to use online resources to make the delivery of introductory science courses more flexible without reducing the learning benefits. McCray (2000) reported the utility of online learning environment in traditional classes in a hybrid course both
as an efficient means for executing activities previously tethered to the classroom setting and as a means to allow the pursuit of higher levels of learning.

Despite the recent advances of blended learning in the field of education, there is little research into how online learning is actually being used in schools by blending face-to-face instruction or how learning platforms can benefit learning. Current evidence and research suggests that the use of online learning platforms is in development stages in all sectors, and is particularly nascent in many secondary schools, with this technology being used mainly to share information or as a document repository. Although learning platforms are designed to impact learning approaches, research findings about these forms of use, or its impact on science learning, its scope for providing learning experiences catering to the needs of students belonging to different learning styles, the difficulties faced by students while learning through online learning platform, are not drawn.

The relatively recent and emerging researches focus on the effect of blended learning on various subjects and in different contexts. As mentioned, several international studies have been conducted in the area of blended learning; most of them are in higher education and in industrial or business environment than in school-level teaching. Research review reveals that there is a lack of studies in Indian educational context on effects of blended learning strategy on science learning at school level. Researchers in India have hardly explored this area of research. In this context, it is critical to design a blended learning strategy in science at secondary school level and to find its effect on higher order thinking and learning science.

1.6 STATEMENT OF THE PROBLEM

Recent developments in science and technology have had a tremendous impact on our ways of living and on our outlook upon the world. Since Science is a way of looking at phenomena as well as factual information about such phenomena, the methods, approaches and strategies employed in science should provide situations in which children have opportunity to explore, to learn independently and to think logically. But too often, science teaching over-emphasizes narrow mastery of the conventional explanations and techniques of established science. With the advent of information and communication technologies such as Internet, students have access to widespread knowledge. Additionally, online learning gives students opportunities to collaborate with the world to internalize their experiences and to have deeper
meaning. But as a discipline, science demands certain modes of learning such as demonstration and experimentation. In this context, it is important to properly blend online learning and face-to-face instruction to ensure or to maximize science learning and develop higher order thinking including critical thinking and problem solving.

Considering this, it was felt that a study which attempts to find the effect of blended learning strategy on higher order thinking and learning science is needed. Hence, the present study titled: “Effect of Blended Learning Strategy on Higher Order Thinking and Learning Science among Secondary School Students” was undertaken.

1.7 OPERATIONAL DEFINITION OF KEY TERMS

**Blended Learning Strategy:** Blended learning strategy is a planned combination of face-to-face instruction and online learning. In the present study, blended learning refers to a pedagogical strategy to engage students in learning of science by blending face-to-face instruction (computer based instruction, lecturing, demonstration, discussion and experimentation) and online learning.

**Higher Order Thinking:** Higher order thinking is a mental process, which leads to higher levels of cognition such as critical thinking and problem solving.

**Critical Thinking:** Critical thinking is a purposeful, self-regulatory judgment, which results in interpretation, analysis, evaluation, and inference as well as explanation. (American Philosophical Association, 1990). The present study defines critical thinking as the person’s ability to use the cognitive skills such as interpretation, analysis, evaluation, inference, explanation and self-regulation when problems/issues in science are presented.

**Problem Solving** Problem solving is defined as a person’s cognitive ability to perform mental operations so as to achieve the goal of solving a problem.

In the present study, problem solving refers to a person’s cognitive abilities involved in solving a problem such as comprehending the problem, clarifying the problem and finding solutions to the problem when problems/issues in science are presented.
In the present study, cognitive abilities such as sensing a problem, defining a problem, analysis of the problem into discrete elements, ability to discriminate between the most relevant and closely related concepts, using analogies for reasoning, using inductive/deductive reasoning, hypothesizing, checking the testability of hypothesis, controlling of variables, prediction, conceiving ideas using diagrammatic representation, conceiving a strategy to execute a plan of action to test the hypothesis, drawing inference from relevant observed data and generalizing were considered as the subcomponents of problem solving.

**Learning Science:** Learning Science is defined as acquisition of facts, concepts, laws, theories and principles in science as well as the proficiency in science process skills.

**Science Process Skills:** Science process skills refer to a set of intellectual skills that are essential for acquiring reliable information about nature. In the present study, science process skills refer to basic science process skills such as observing, comparing, classifying, quantifying, communicating and predicting.

**Science Achievement:** Science achievement refers to knowledge, understanding and application of scientific facts, concepts, laws, theories and principles pertaining to the selected content of ninth standard science curriculum.

**Learning Style:** Characteristic ways (visual, auditory, kinesthetic) through which learners perceive, interact with and respond to their learning environment.

**1.8 VARIABLES OF THE STUDY**

Real science learning encompasses not only the acquisition of science facts, concepts, theories etc but also the development of process skills as well as higher order thinking among students. In the present study, the teaching strategy is taken as the independent variable wherein blended learning strategy is employed as the experimental intervention for teaching science. The dependent variables considered in the present study are critical thinking, problem solving, science achievement and science process skills. Besides this, learning style is considered as a moderator variable and it was attempted to study the differential effect of blended learning
strategies with respect to learning style of experimental group students on the dependent variables.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Dependent Variable</th>
<th>Moderator variable</th>
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<tbody>
<tr>
<td>Teaching Strategy</td>
<td>Critical Thinking</td>
<td>Learning Style</td>
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<td></td>
<td>Problem Solving</td>
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<td>Science Achievement</td>
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<td>Science Process Skills</td>
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1.9 OBJECTIVES OF THE STUDY
1. To find the effect of blended learning strategy on students’
   a) Critical thinking
   b) Problem solving
   c) Science process skills
   d) Science achievement

2. To find the difference in
   a) Critical thinking
   b) Problem solving
   c) Science process skills
   d) Science achievement
   among experimental group students with different learning styles as an effect of blended learning strategy

3. To find the reaction of students towards blended learning strategy

4. To identify the difficulties faced by students while learning science through blended learning strategy
1.10 HYPOTHESES

1. Blended learning strategy is more effective than the conventional method of teaching in enhancing students’
   a) Critical thinking
   b) Problem solving
   c) Science process skills
   d) Science achievement

2. There is no difference in
   a) Critical thinking
   b) Problem solving
   c) Science process skills
   d) Science achievement

   among visual, auditory and kinesthetic learners of the experimental group as an effect of blended learning strategy

1.11 RESEARCH QUESTIONS

1. What are the reactions of students towards blended learning strategy?
2. What are the difficulties faced by students while learning science through blended learning strategy?

1.12 DELIMITATIONS OF THE STUDY

1. The study was confined only to ninth standard students.
2. The intervention was carried out only for six units of ninth standard science curriculum.
3. Online learning activities included sharing information through message board, emails, online publishing of articles, uploading multimedia, online submission of assignments and online projects only and excluded online activities like synchronous online tutoring.
1.13 SUMMARY

In this chapter on theoretical background of the study, blended learning is presented as a strategy for maximizing science learning. Various models of blended learning and its components are explained in detail. A detailed description of variables – critical thinking, problem solving, science achievement and science process skills are also presented specifying their dimensions. This chapter also examined the relevance and significance of these variables as science learning outcomes. Rationale and significance of the study are explained in detail. Objectives and hypothesis of the study are stated and research questions are presented. Additionally, this chapter provided operational definitions of key terms, classification of variables and delimitations of the study.