CHAPTER-III
CONCEPTUAL FRAME WORK

3.1. INTRODUCTION
3.2. DEFINITIONS FOR METACOGNITION
3.3. METACOGNITIVE AWARENESS
3.4. THEORIES OF METACOGNITION
3.5. PHYSIOLOGICAL ASPECTS OF METACOGNITION
3.6. METACOGNITION AND MEASUREMENT
3.7. METACOGNITIVE STRATEGIES
3.8. METACOGNITIVE TRAINING STRATEGIES
3.9. METACOGNITIVE INTERVENTIONS STRATEGIES TO ENHANCE COMPETENCY IN TEACHING SCIENCE.
   3.9.1. EXPLICIT INSTRUCTION
   3.9.2. MODELING
   3.9.3. INTERACTION
   3.9.4. GUIDED PRACTICE
   3.9.5. SYSTEMATIC FEEDBACK
   3.9.6. INSTRUCTIONAL TIME
3.10. METACOGNITIVE ENVIRONMENT IN SCIENCE CLASS ROOM
3.11. ROLE OF SCIENCE TEACHERS
3.12. DESIRABLE COMPETENCIES AND SKILLS FOR SCIENCE TEACHERS
   3.12.1. SCIENCE PROCESS SKILLS
   3.12.2. INSTRUCTIONAL SKILLS
   3.12.3. INFORMATION PROCESSING SKILLS
   3.12.4. DECISION MAKING SKILLS
3.12.5. TRAINING IN INSTRUCTIONAL COMPETENCIES
3.12.6. EXPERIMENTAL SESSION
3.12.7. EVALUATION OF CLASS ROOM STUDENTS

3.13. MOTIVATION

3.14. THEORIES OF MOTIVATION

3.15. ROLE OF MOTIVATION IN EDUCATION

3.16. PHYSIOLOGICAL ASPECTS OF MOTIVATION

3.17. MOTIVATIONAL STRATEGIES
CHAPTER III

CONCEPTUAL FRAME WORK

3.1. INTRODUCTION

"Metacognition" is one of the latest buzz words in educational psychology, but what exactly is metacognition? The length and abstract nature of the word makes it sound intimidating. We engage in metacognitive activities everyday. Metacognition enables us to be successful learners, and has been associated with intelligence (e.g., Borkowski, Carr, & Pressley, 1987; Sternberg, 1984, 1986a, 1986b). Metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning. Activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive in nature. Because metacognition plays a critical role in successful learning, it is important to study metacognitive activity and development to determine how students can be taught to apply better their cognitive resources through metacognitive control.

"Metacognition" is often simply defined as "thinking about thinking." In actuality, defining metacognition is not that simple. Although the term has been part of the vocabulary of educational psychologists for the last couple of decades, and the concept for as long
as humans have been able to reflect on their cognitive experiences, there is much debate over exactly what metacognition is. One reason for this confusion is the fact that there are several terms currently used to describe the same basic phenomenon (e.g., self-regulation, executive control), or an aspect of that phenomenon (e.g., meta-memory), and these terms are often used interchangeably in the literature. While there are some distinctions between definitions all emphasize the role of executive processes in the overseeing and regulation of cognitive processes.

The term "Metacognition" is most often associated with John Flavell, (1979). According to Flavell (1979, 1987), metacognition consists of both metacognitive knowledge and metacognitive experiences or regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes, knowledge that can be used to control cognitive processes. Flavell further divides metacognitive knowledge into three categories: knowledge of person variables, task variables and strategy variables.

3.2. DEFINITIONS FOR METACOGNITION

"Metacognition is the knowledge and awareness of one's own cognitive processes (Flavell 1976) and the ability to monitor, regulate and evaluate one's thinking" (Brown 1978).
"Metacognitive processes enable individuals to better control their thinking and thereby become more efficient and flexible learners" (Shore & Dover 1987).

Metacognitive skills include checking, planning, selecting, monitoring, self-questioning, and interpreting on-going experience (Brown, Campione, Flavell & Wellman).

Metacognition is the conscious control over the solution process (Shore & Carey 1984)

Metacognition is an indicator of the educated intellect (Costa 1991).

Metacognition is the state where one is conscious of one's thinking and problem solving (Cohen 1994)

Flavell (1979) defines metacognition as “Knowledge and cognition about cognitive phenomena”.

Knowledge about one's own cognitive system, thinking about one's own thinking, essential skill for learning to learn, includes thoughts about (what we know or don't know and regulating how we go about learning).
"Knowing about knowing" knowledge and awareness of our own cognitive process, how they function, when it's likely to falter, etc. Metacognition is thinking about thinking, knowing "what we know" and "what we don't know".

Flavell & Wellman (1977) defined "Metacognitive Knowledge as the knowledge learners have about themselves, about task characteristics and about strategies".

"Having knowledge (cognition) and having understanding, control over, and appropriate use of that knowledge" (Tei & Stewart, 1985).

Executive monitoring processes are those that are "directed at the acquisition of information about the person's thinking processes" (Kluwe, 1982, p. 212).

According to Sternberg, metacomponents are responsible for "figuring out how to do a particular task or set of tasks, and then making sure that the task or set of tasks are done correctly" (Sternberg, 1986 b, p. 24).

Metacognition refers to the ability of learners to be aware of and monitor their learning processes (Peters 2000).
Taylor (1999) defines Metacognition as “an appreciation of what one already knows, together with a correct apprehension of the learning task and what knowledge and skills it requires, combined with the ability to make correct inferences about how to apply one’s strategic knowledge to a particular situation, and to do so efficiently and reliably”.

(Schunk & Zimmerman, 1994; Winne, 1995; Zimmerman, 1994).

“Self-Regulation refers to students' ability to understand and control their learning”

(Baker, 1989 Schraw & Moshman, 1995). “Metacognition includes two main components referred to as knowledge of cognition and regulation of cognition” e.g., (Billingsley & Wildman, 1990) In general, Metacognition refers to knowledge and self-regulation of one's own learning processes.

The following definitions were found on metacognition in the web:

Thinking about one's thinking; the monitoring of one’s thinking for the critical thinking criteria as one is acquiring and assessing new information. For scientific thinking, this means also becoming aware of one's background knowledge, assumptions, and the auxiliary hypotheses (how observing works) and assessing their validity as well.
The process of considering and regulating one's own learning. Activities include assessing or reviewing one's current and previous knowledge, identifying gaps in that knowledge, planning gap-filling strategies, determining the relevance of new information, and potentially revising beliefs on the subject.

An individual's ability to reflect on one's own thinking and to monitor one's own learning. Metacognition is integral to a learner's ability to actively participate in his/her own learning and to facilitate transfer of learning to other contexts. (Bransford, Brown & Cocking, 1999).

The knowledge of one’s own thinking processes and strategies, and the ability to consciously reflect and act on the knowledge of cognition to modify those processes and strategies.

The process of knowing or thinking about how we use strategies and skills to enhance our thought processes; thinking about how we think.

Thinking about the thinking process; the management of thinking.

Metacognition is the process of thinking about what we know and what we don't know. At the beginning of a research or learning unit, it is always good for students to evaluate their background knowledge related to the topic under consideration in order to identify what is new.
knowledge and establish the connection between new and background knowledge. For more details on Metacognition.

The process of thinking about and regulating one's own learning. Examples of metacognitive activities include assessing what one already knows about a given topic before reading, assessing the nature of the learning task, planning specific reading/thinking strategies, determining what needs to be learned, assessing what is comprehended or not comprehended during reading, thinking about what is important and unimportant, evaluating the effectiveness of the reading/thinking strategy, revising what is known, and revising the strategy.

Awareness of a person's own mental processes.

A person's reflection on his or her own thinking processes. By using metacognitive skills, readers are able to make judgments about whether or not they understand what they read.

3.3. METACOGNITIVE AWARENESS

Knowledge and strategies in isolation are not sufficient for self-regulation. Students must understand the strengths and limitations of their knowledge and strategies in order to be able to use them efficiently. Educational psychologists refer to this capability as Metacognition, or explicit knowledge of one's own cognition. Metacognition includes two main components referred to as knowledge of cognition and regulation of
cognition (Baker, 1989; Schraw & Moshman, 1995). Knowledge of cognition consists of explicit knowledge of our memory, knowledge base, and strategy repertoire, as well as what is often known as conditional knowledge, or knowledge about why, when and where to use strategies. Regulation of cognition consists of knowledge about planning, monitoring, and evaluation.

Metacognition consists of three basic Elements

a. Developing a plan of action.

b. Maintaining /monitoring the plan.

c. Evaluating the plan.

3.4. THEORIES OF METACOGNITION

Empirical Theories

Flavell’s Theory: In 1977, Flavell and Wellman proposed a theory of metamemory to explain young children’s development and application of recall strategies (or lack thereof). Flavell and Wellman hypothesized that young children's failure to apply strategies for recalling information was because of their lack of awareness of "parameters that govern effective recall" (Wong, 1995,). Consequently, he concluded that their failure to recall resided in a deficiency in metamemory.

Flavell's (1979) model of Metacognition and cognitive monitoring developed from answers to many of those questions. According to his model, a person's ability to control "a wide variety of cognitive
enterprises occurs through the actions and interactions among four classes of phenomena: (a) metacognitive knowledge, (b) metacognitive experiences, (c) goals (or tasks), and (d) actions (or strategies). Metacognitive knowledge refers to one's stored world knowledge that "has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences." It consists of one's knowledge or beliefs about three general factors: his or her own nature or the nature of another as a cognitive processor; a task, its demands, and how those demands can be met under varying conditions; and strategies for accomplishing the task (i.e., cognitive strategies that are invoked to make progress toward goals, and metacognitive strategies that are invoked to monitor the progress of cognitive strategies). Metacognitive knowledge may influence the course of cognitive enterprises through a deliberate and conscious memory search or through unconscious and automatic cognitive processes. Metacognitive knowledge may lead to a wide variety of metacognitive experiences, which Flavell describes as conscious cognitive or affective experiences that accompany and pertain to an intellectual enterprise.

**Kluwe's Theory (1982):** It identifies two general attributes a) thinking subject has some knowledge about his own thinking (declarative knowledge) "stored data in long-term memory" b) thinking
subject may monitor or regulate the course of his own thinking (Procedural knowledge).

**Annbrown’s theory:** Brown (1980) applied metacognitive theory to reading and differentiated between cognitive and metacognitive processes. She identified metacognitive processes as reader-controlled strategies that included selecting and studying the most important part of text, selecting retrieval cues, and estimating readiness for tests. She emphasized the importance of the executive control, in developing memory skills.

**John Borkowski’s theory:** It includes the understandings of a strategy, value of using a strategy, goal of strategy, range of applicability, use of strategy. Borkowski, Johnston, and Reid (1987) emphasized motivation and the retraining of students' attribution beliefs about success from external control (e.g., luck, teacher, ease of task) to self (e.g., value of using a strategy). While recognizing the role of self-regulation and motivation in Metacognition, he emphasized self-awareness and self-efficacy. He suggested the method of strategy teaching

**Robert.J.Sternberg’s theory:** This consists of performance (encoding, decoding, mapping application, and justification) and acquisition components (Selective encoding, selective combination and selective comparison). These components represent automated cognitive
and selective processes used in learning, respectively. Sternberg considers metacomponents to be key features of intelligence. The skills such as identifying the nature of problem, planning, and monitoring, are consistent with characteristics associated with Metacognition. Metacomponents are associated with adaptive behaviors. These adaptive behaviors are functional strategies, or act on performance and knowledge acquisition components. Adaptive behaviors goes beyond the knowledge and cognitive abilities measured by intelligence tests, and represents the ability to use these aptitudes to adapt to, select, or shape one’s environment.

Paris and Wino grad’s Theory (1990): In this theory he identified two essential features of Metacognition, self-appraisal and self-management. Self-appraisal is people’s personnel reflections about their knowledge states and their affective states of knowledge abilities (motivation). Such reflections answer questions about what you know, how you think, and when & why to apply knowledge or strategies. Self-management refers to “Metacognition in action” i.e. the process helps to orchestrate aspects of problem solving.

Reviewing Theories related to Metacognition

The following are the reviewing theories found in the literature of Metacognition:
Executive control

Executive function is indicated when a child alters strategic behavior over the course of a task in order to solve it. Belmont, Butterfield & Ferretti, 1982 suggest that there exist three general executive skills such as anticipation, strategy planning and self-control. Meta knowledge is thus supposed to be the knowledge base of executive functions at a metacognitive level, which in turn controls cognitive processes at a cognitive level. If we want to secure transfer in learning we have to instruct executive skills. Executive skills are important for efficient and effective learning because they assist in the performance of cognitive strategies. Thus, there is a functional relation between transfer and learning.

Executive processes involve both monitoring and regulating other thought processes, and therefore, correspond with Flavell's (1979) metacognitive strategies and Brown's (1978) metacognitive skills.
Executive monitoring processes are those that are "directed at the acquisition of information about the person's thinking processes" (Kluwe, 1982). They involve one's decisions that help to identify the task on which one is currently working, to check on current progress of that work, to evaluate that progress, and to predict what the outcome of that progress will be. Executive regulation processes are those that are "directed at the regulation of the course of one's own thinking". They involve one's decisions that help to allocate his or her resources to the current task, to determine the order of steps to be taken to complete the task, and to set the intensity or the speed at which one should work the task.

**Metacognitive Knowledge**

Metacognition includes two main components referred to as knowledge of cognition and regulation of cognition (Baker, 1989; Schraw & Moshman, 1995). Knowledge of cognition consists of explicit knowledge of our memory, knowledge base, and strategy repertoire, as well as what is often known as conditional knowledge, or knowledge about why, when and where to use strategies. Regulation of cognition consists of knowledge about planning, monitoring, and evaluation.

Metacognitive knowledge refers to one's stored world knowledge. It consists of one's knowledge or beliefs about three general factors: his or her own nature or the nature of another as a cognitive processor; a task, its demands, and how those demands can be met under varying
conditions; and strategies for accomplishing the task. Metacognitive knowledge may influence the course of cognitive enterprises through a deliberate and conscious memory search or through non conscious and automatic cognitive processes.

Finally, knowledge about strategy variables include knowledge about both cognitive and metacognitive strategies, as well as conditional knowledge about when and where it is appropriate to use such strategies. Flavell himself acknowledges that metacognitive knowledge may not be different from cognitive knowledge (Flavell, 1979). The distinction lies in how the information is used.

To increase their metacognitive abilities, students need to possess and be aware of three kinds of content knowledge: declarative, procedural, and conditional. Declarative knowledge is the factual information that one knows; it can be declared, spoken or written. Procedural knowledge is knowledge of how to do something, how to perform the steps in a process. Conditional knowledge is knowledge about when to use a procedure, skill, or strategy and when not to use it; why a procedure works and under what conditions; and why one procedure is better than another.
**Metacognition and Intelligence**

Metacognition, or the ability to control one's cognitive processes (self-regulation) has been linked to intelligence (Borkowski et al., 1987; Brown, 1987; Sternberg, 1984, 1986a, 1986b). Sternberg refers to these executive processes as "metacomponents" in his triarchic theory of intelligence (Sternberg, 1984, 1986a, 1986b). Sternberg maintains that the ability to appropriately allocate cognitive resources, such as deciding how and when a given task should be accomplished, is central to intelligence.

Sternberg’s model also consists of performance (encoding, decoding, mapping application, and justification) and acquisition components (Selective encoding, selective combination and selective comparison). These components represent automated cognitive and selective processes used in learning. Sternberg considers metacomponents to be key features of intelligence. The skills such as identifying the nature of problem, planning, and monitoring, are consistent with characteristics associated with Metacognition. Metacomponents are associated with adaptive behaviors. These adaptive behaviors are functional strategies, or act on performance and knowledge acquisition components. Adaptive behaviors goes beyond the knowledge and cognitive abilities measured by intelligence tests, and represents the ability to use these aptitudes to adapt to, select, or shape one’s environment.
Brown states that highly developed metacognitive skills are characteristics of high intelligence. By developing self-awareness, one is effectively developing one's intelligence.

**Cognitive Monitoring**

Knowing whether students accurately monitor their knowledge and thought process, and whether memory monitoring complex tasks can be taught to younger children are the concerns of teachers, researchers, and theoreticians of self-regulation of learning.

To investigate the knowledge of student’s knowledge and monitoring thought process the following metacognitive phenomena are used. Feeling of Knowing (FOK), serial recall, allocation of study effort, and Judgement of Learning (JOL).

**Bisanz, Vesonder, and Voss (1978)** showed that there are developmental differences between young and older children in the ability to monitor the current knowledge in memory and how the results of monitoring are used in the allocation of study effort. Monitoring ability increases with age. Moreover, older students were more inclined than younger students to use memory-monitoring information to allocate greater study to those items they had monitored as incorrect.

**Nelson and Dunlosky (1991)** found that JOL made after a delay were more accurate than JOL made immediately or shortly after learning.
METACOGNITIVE SYSTEM
Generalized Knowledge and control schemata/self awareness/self regulation strategies and memories

AFFECTIVE SYSTEM Generalized personality schemata/traits/motivational strategies and memories of feelings memories/feelings

COGNITIVE SYSTEM Generalized Cognitive schemata/abilities/information processing strategies memories of knowledge

Task initiation

Perceptions of task requirements

Perceptions of personal control

Outcome expectations

Initial Intrinsic interest / Motivation level

Efficiency expectation

Task engagements

Awareness of relevant strategies

Perceptions of Strategy utility and cost

Attentional strategies

Information encoding/retrieval strategies

Metacognitive strategies

Rehearsal strategies

Reevaluations of personal control

Reevaluations of outcome Expectancies

Reevaluations of efficacy expectations

Execution of appropriate learning and self-management strategies

Task completion

Performance level evaluations

Success/failure attributions

Self efficacy judgments and feelings

Personal control judgments and feelings

Generative model of processes and skills underlying continuing motivation to learn McCombs, 1984
A person should monitor long-term memory because future test performance depends upon knowledge in long-term memory.

Overall research in memory monitoring has shown that even kindergardeners can accurately monitor their knowledge. With increase in age, however, people gain not only in the amount of knowledge that can be held in memory, but gain in how accurately they can monitor their knowledge.

Thus, in determining whether people can accurately monitor their memories, it is important to consider whether it is long or short-term memory that is being monitored. When memory monitoring tasks are simple and do not overload working memory (e.g., simple recall or recognition tasks) there is little difference between younger and older children (Schneider, 1985). But as the complexity of tasks increases, the difficulty in monitoring the thought processes necessary to complete them also increases (Schneider, 1985).

Retrospective monitoring is judgment about what was previously retrieved from memory and Prospective monitoring is predictive about information available. The different types of prospective monitoring judgments are:
**Ease of Learning (EOL)** judgments: occur in advance of acquisition of knowledge, and predictions about what information and strategies will be the easiest to learn.

**JOL**: occur during or after knowledge acquisition, and predictions about future test performance on currently recallable items.

**FOK**: occur during or after knowledge acquisition, and judgments about a currently unrecallable items is known and/or will be remembered on a later memory test.

Metacognitive research includes studies in which people monitor available information during the course of their own thinking and then use this information to regulate subsequent memory processes (Kluwe, 1982; Schneider, 1985; Schoenfeld, 1987). Paris and Winograd (1990) refer to this category of research as studies of self management, which is Metacognition in action. This helps to orchestrate aspects of problem solving which includes the plans that learner make before tackling a task, the adjustments they make as they work, the revisions they make afterwards, and how learner regulate his selection of strategies based on information he monitors while employing the strategies. People are assumed to have monitored and regulated their use of strategies if they select more efficacious one (Levin and Ghatala (1984)).
The use of monitoring checklists in which students check off component steps helps to systematize monitoring (Schraw, 1998b). The checklist shown below provides an example:

- What is the purpose for learning this information?
- Do I know anything about this topic?
- Do I know strategies that will help me learn?
- Am I understanding as I proceed?
- How should I correct errors?
- Have I accomplished the goals I set myself?

Studies that have used checklists report favorable findings, especially when students are learning difficult material (Delclos & Harrington, 1991; King, 1991).

Cognitive Regulation

Butterfield & Ferrett, (1987) Cavanaugh & Borkowski, (1979), Moynahan, (1978) showed that young children can be trained to monitor their strategic behavior and performance and that this training can enhance their regulation of efficient strategies.

Educators are interested in self-regulation of Learning. The most effective learners are self-regulating (Butler & Winne, 1995). Effective self-regulation is self assessment of what is known or not known (Schoenfeld, 1987).
Self-Regulation refers to students' ability to understand and control their learning (Schunk & Zimmerman, 1994; Winne, 1995; Zimmerman, 1994). Key to effective self-regulation is accurate self-assessment of what is known or not known (Schoenfeld, 1987). Only when students know the state of their own knowledge they can effectively self-direct learning to the unknown. Therefore, knowing whether students can accurately monitor their knowledge and thought processes, and whether memory monitoring of complex tasks can be taught to younger children are key concerns of teachers, researchers, and theoreticians interested in encouraging self-regulation of learning.

Self-regulation includes coordinating metacognitive knowledge such as self-knowledge and knowledge of text organization, planning, monitoring understanding, and identifying and remediation causes of failures. Although the metacognitive components of knowledge and self-regulation can be distinguished from each other, Brown (1987) suggested that attempts to separate components may lead to "oversimplification" of a complex process.

Regardless of one's commitment, we believe that even a small amount of time invested in helping students appreciate the importance of self-regulation can lead to a noticeable improvement.
Awareness to the students about self regulation consist of Relevant knowledge base, Repertoire of specific and general strategies, Motivational beliefs that support self-regulation, Role of teacher feedback and modeling, Foster an understanding of the knowledge base, Organized factual knowledge, Main concepts, principles, and theories, Procedural skills necessary to perform competently, Enhance strategy repertoires, Course-specific strategies, General strategies (summarizing and comprehension monitoring), Nurture appropriate motivational beliefs, High self-efficacy, Attributions to controllable causes (e.g., effort), Provide practice using informational feedback from teachers, students, Enhance metacognitive awareness of their own learning, increase the learner's awareness of his or her own knowledge base, knowledge about how, when, and where to use strategies, knowledge about how to plan.

Automation of cognitive and Metacognitive processes

Kevin Crowley and his associates have demonstrated the relationship between automation of cognitive process and the emergence of Metacognitive thinking. Theory found that kindergarten children were most likely to think metacognitively when the lower cognitive skill became automated. The strategies became associative mechanisms which operate without conscious effort. It involves processes such as review, reflection, and deliberation.

Review: to look over, examine, or study past experiences.
**Reflection:** to reflect personal skills and past experience to a current task.

**Deliberation:** to consider the thoughtfulness of current actions and decisions.

**Private Speech and Development of Metacognition**

Barenda Manning and her associates studied the development of self-regulatory skills in children based on Lev Vygostky's private speech as a precursor to self-regulatory behavior. Much of work followed by Vygotsky suggested that private speech disappears or is replaced by internalized speech in middle childhood. A performance score reveals that the lower scoring students focus private speech on negative statements about self or the task, while higher scoring students favor and use it as a strategy.

**The Social and Emotional Aspects of Metacognition**

John Borkowski and his associates have distinguished between types of strategy knowledge. This includes what a particular strategy would achieve, range of its usefulness what are the benefits of regularly using it, how much laborious or enjoyable it would be. As children experience success or failure and they receive feedback occurring frequently develop into attributions of success and failure. These attributions govern self-esteem and self-efficacy, and the effects they have on successful strategy learning and transfer to other content areas.
Borkowski reviewed a number of studies, which points to the importance of attributions training to students with learning difficulties. Recent studies indicate in importance of individual's beliefs, attitudes and expectations.

**Metacognitive Skills**

Although related, cognition and metacognition differ. Cognitive skills are those needed to perform a task whereas metacognitive skills are necessary to understand how it was performed (Rivers 2001; Schraw 1998). Metacognitive skills are generally divided into two types: self-assessment (the ability to assess one's own cognition) and self-management (the ability to manage one's further cognitive development) (Rivers 2001). Successful adult learners employ a range of metacognitive skills and effective teachers of adults attend to the development of these skills.

Metacognitive skills are important not only in school, but throughout life. For example, Mumford (1986) says that it is essential that an effective manager be a person who has learned to learn. While it is occasionally useful to consciously reflect on one's metacognitive processes and while it useful to make learners aware of these processes while they are trying to acquire them, these skills become most effective when they become over learned and automatic. If these skills were not automatic and unconscious, they would occupy some of the effort of the
working memory; and this would have the result of making reading,
listening, and other cognitive activities less efficient. Therefore, like any
other skill that becomes automatic and requires minimal activity in the
working memory, metacognitive skills work best when they are over
learned and can operate unconsciously.

Learners with good metacognitive skills are able to monitor and
direct their own learning processes. Students typically learn
metacognitive skills while they are involved in learning something else. If
they are to do this successfully, it is extremely important that the learners
have over learned the prerequisite content knowledge for the subject
matter topic being studied. If that prerequisite knowledge has not been
mastered to a sufficient level of automaticity, then the working memory
of the learner will be overwhelmed by the subject matter; and the result
will be no time for metacognitive reflection.

Trends in the literature on Metacognition can be grouped around
the two types of metacognitive skills. Literature on self-assessment deals
with the importance of learners being able to assess their knowledge and
abilities. Research indicates that learners who are skilled in metacognitive
self-assessment and, therefore, aware of their abilities are more strategic
and perform better than those who are unaware (Rivers 2001; Schraw and
Dennison 1994). Examples of instruments for assessing metacognitive
skills can be found in Mokhtari and Sheorey (2002) and Schraw and Dennison (1994). The use of such instruments can help learners to incorporate strategies that will improve Metacognition (Mokhtari and Sheorey 2002).

3.5. PHYSIOLOGICAL ASPECTS OF METACOGNITION

Role of Neural Circuit in Metacognition

The relationship between Metacognition and executive control is explored. According to an analysis by Fernandez-Duque, Baird, and Posner, the aspects of Metacognition are presumed to be mediated by a neural circuit involving mid frontal brain regions.

They emphasize the biological bases of Metacognition and suggest that mid frontal brain regions are part of a neural circuit that enables metacognitive regulation.

There is evidence to suggest that the frontal cortex contributes to Metacognition. Indeed, impairments in metacognitive monitoring can be observed in patients with frontal lobe damage.

Another aspect of metacognitive evaluation is source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). In source monitoring tasks, subjects must evaluate contextual information, such as remembering when or where some event occurred or who presented some information.
In another study (Janowsky, Shimamura, & Squire, 1989b), patients with frontal lobe lesions exhibited significant problems in source monitoring.

Recently, functional neuro imaging studies have affirmed the role of the frontal cortex in source monitoring and retrieval. In an event-related fMRI study, Nolde, Johnson, and D'Esposito (1998) asked persons to remember whether a previously studied item was originally presented as a word or picture. Left prefrontal activation was associated with the retrieval of source information. This finding has been replicated in another fMRI study in which persons were required to remember whether a previously presented word had been presented on the left or right side (Rugg, Fletcher, Chua, & Dolan, 1999).

These findings suggest that the frontal cortex contributes to Metacognition (e.g., feeling-of-knowing judgments, source monitoring). On the other hand, investigations of executive control have assessed and defined specific components—such as selecting stimulus information, maintaining information in working memory, and manipulating information processing. Thus, the linking of Metacognition to aspects of executive control offers opportunities to define better cognitive components of Metacognition.
Working Memory and Prefrontal Cortex

The Nelson-Narens (1990) idea of metacognitive control is quite similar to the idea of executive control. Working memory refers to the processes and representations involved in the temporary activation or storage of information. In this and other views of working memory (Cowan, 1988; Shimamura,), executive control can be defined as processes involved in the selection, activation, and manipulation of information in working memory. In terms of the Nelson-Narens (1990, 1994) model, object-level information that is being monitored is in working memory, and top-down control of that information involves meta-level control.

Baddeley (1986) sharpened understanding of the role of the frontal cortex in terms of its role in executive control of working memory. Recently, the notion of executive control has been refined and developed even further (Petrides, 1998; Shimamura, 2000b; Smith & Jonides, 1999).

Shimamura identified four aspects of executive control selecting, maintaining, updating, and rerouting. Selecting refers to the ability to focus attention to stimulus events or activate memory representations. Maintaining refers to the ability to keep active information in working memory. Updating refers to the ability to modulate and rearrange activity
in working memory. Rerouting refers to the ability to switch from one cognitive process or response set to another.

Maintaining information in working memory has also been associated with activation in frontal cortex. Impairment of immediate memory has been observed in patients with frontal lobe lesions on a variety of span tests, such as those involving numeric, spatial, color, or auditory stimuli (Baldo & Shimamura, in press; Chao & Knight, 1998; Janowsky, Shimamura, Kritchevsky, & Squire, 1989; Ptito, Crane, Leonard, Amsel, & Caramanos, 1995). Moreover, neuro imaging studies have affirmed the role of the prefrontal cortex in maintaining both object and spatial information in working memory (Awh, Jonides, Smith, Schumacher, & Koepppe, 1996; Jonides et al., 1993; McCarthy, Blamire, Rothman, Gruetter, & Shulman, 1993; Smith, Jonides, Koepppe, Awh, Schumacher, & Minoshima, 1995). Interestingly, Smith et al. (1995) found posterior left-hemisphere activation for object short-term memory, but posterior right hemisphere activation for spatial short-term memory. These findings suggest neural circuitry involving the participation of prefrontal regions with posterior cortical regions.

Theories of Executive Control and Frontal Lobe Function is one of the few computational models that have addressed specifically metacognition and frontal lobe function, and known as Metcalfe’s
CHARM model (Metcalfe, 1993). In her model, metacognitive evaluations, such as feelings of knowing, are based on a familiarity check that is computed between new information and what is already stored in memory.

3.6. METACOGNITION AND MEASUREMENT

Measuring metacognitive processes has been difficult. Many of the instruments developed to measure have suffered from criticisms about their validity. The vast and majority of current metacognitive measures are self reports, these include retrospective verbal reports, in which individual recall what they are thinking while they are doing a task. Concurrent verbal reports in which recording their thinking while thinking occurs, interferes with cognitive processing in progress.

Written reports in which individual record his or her thinking in response to standardized questions following a task. They rely on memory and limited by the standard questions they ask. Self-estimates, which an individual estimates their performance on a task prior to or after. Retrospective interviews on completion of a task rely on often-vague memories of one’s thinking during a problem solving.

One of the most commonly used measures of metacognition has been the “Feeling of Knowing” (FOK), after failing to answer a test item, individuals are asked to judge how well they think they would do in a
multiple choice recognition test in which one of the alternatives was the correct answer.

Ease Of Learning (EOL) also called confidence judgments or self-estimates, are another measure of Metacognition, in which the individuals predict, given a test’s requirements, how well they think and perform on it.

**JOL** have individuals predict how well they did on a test just completed. Predicted and actual performances are compared.

Like definitions and theories, variations exist in methods used to measure metacognition. The measures most commonly used to define and assess metacognition include self-talk, self-report, and questionnaires. However, these measures often lack reliability (Brown, 1987) and therefore complicate interpretation of findings.

Self-talk (i.e., explaining one's thinking processes and strategies) during problem-solving is problematic because students, especially young children, may be incapable of simultaneously solving problems and commenting on the problem-solving process (e.g., Brown, 1987). In the case of retrospective self-reports (i.e., reporting one's thinking processes and strategies after-the-fact), adults, as well as young children, may have difficulty reporting their thinking processes, therefore making self-report
an inconsistent measure (Ericsson & Simon; Nisbet & Wilson; Smith & Miller; White; cited in Brown, 1987). Young children may reconstruct past events inaccurately and modify observations of their thought processes (e.g., Piaget, cited in Brown, 1987). Moreover, thought processes during problem-solving may be transient (i.e., existing only during a particular task or context) and therefore more difficult to report than metacognitive knowledge (i.e., knowledge of self as a learner, task demands, necessity to amend learning activities to match specific tasks) that is more stable. Additionally, self-talk and retrospective self-reports are problematic because skilled readers perform tasks automatically and are unlikely to think about underlying metacognitive processes. Furthermore, students with learning disabilities may not possess the language skills to report their metacognitive processes (Billingsley & Wildman, 1991).

Interactions between context and a student's prior experience also confound the measurement of Metacognition. Individuals do not demonstrate the same metacognitive difficulty or expertise in every situation (Meltzer, 1993). Performance on measures of metacognitive procedures depends upon task complexity and may be heavily influenced by a student's prior experience with the task and familiarity with the type of information required for the task (Torgesen, 1994).
3.7. METACOGNITIVE STRATEGIES

Strategies refer to learning tactics used intentionally to accomplish a specific goal or purpose (Dole, Duffy, Roehler, & Pearson, 1991). They are essential to effective learning for several reasons. They enable learners to use their limited cognitive resources more efficiently, approach problems more systematically, and increase positive motivational beliefs such as self-efficacy.

Cognitive strategies are broad array of learner-based actions that help control attention, behavior, communication, emotions, motivation, and comprehension (Weinstein & Mayer, cited in Paris et al., 1991).

Most definitions of metacognition include both knowledge and strategy components. Cognitive strategies are used to help an individual to achieve a particular goal while metacognitive strategies are used to ensure that the goal has been reached.

Metacognitive and cognitive strategies may overlap in the same strategy, such as questioning, could be regarded as either a cognitive or a metacognitive strategy, depending on what purpose the strategy is being used. Because cognitive and metacognitive strategies are closely interwined and dependent upon each other, any attempt to examine one without acknowledging the other would not provide an adequate picture.
Learning how to learn, developing thinking processes, which can be applied to solve problems, is a major goal of education. When life presents situations that cannot be solved by learned responses, the metacognitive behavior is brought in to play.

Metacognitive skills are needed when habitual responses are not successful. Guidance in recognizing, and practice in applying, metacognitive strategies will help students successfully solve problems throughout their lives.

Two important characteristics of any effective metacognitive strategy are that it must be memorable and it must accurately represent the learning task. Metacognitive strategies positively impact students who have learning problems because they provide these students an efficient way to acquire, store, and express information and skills (Mercer & Mercer, 1993). Well developed metacognitive strategies aid information retrieval for the students. The key to the success of metacognitive strategies is that when they are taught appropriately, they assist learners who are dependent on high levels of teacher support to become independent learners. When students have been directly taught the strategy, the strategy’s purpose, how to use the strategy, and are provided opportunities to practice using the strategy, these students’ posses a powerful learning tool that builds learning independence.
A potential misconception about metacognitive strategies is that they, in and of themselves, cure learning problems. This perception may lead some teachers to simply supply the student with a copy of a strategy without directly teaching the strategy to the student. When the student does not use the strategy, or doesn’t use it appropriately, the teacher may conclude that the metacognitive strategy is not helpful. It is important to remember that metacognitive strategies are like any skill we want students to learn. Metacognitive strategies need to be taught! This is especially true for students who have learning problems.

The basic metacognitive strategies (Dirkes, 1985) are,

- Connecting new information to former knowledge.
- Selecting thinking strategies deliberately.
- Planning, monitoring, and evaluating thinking process.

Studies show that metacognitive strategies increase learning. Direct teaching of above thinking strategies may be useful, and that independent use develops gradually (Scruggs, 1985). Recognizing, and applying in practice, metacognitive strategies, will help students successfully solve problems.

**Strategies for developing metacognitive behaviors are,**

- Identifying: At the beginning of a activity students need to make conscious decisions about their knowledge.
Talking about thinking: Talking about thinking is important because students need a thinking vocabulary. During planning and problem-solving situations, teachers should think aloud so that students can follow demonstrated thinking processes, modeling and discussion.

Keeping a thinking journal: This is a diary in which students reflect upon their thinking, make note of their awareness of ambiguities, inconsistencies and comment on how they have dealt with difficulties.

Planning and self-regulation: It is difficult for learners to become self-directed when learning is planned and monitored by someone else, students can be taught to make plans for learning activities including estimating time requirements, organizing materials, and scheduling procedures necessary to complete an activity.

Debriefing the thinking process: A three-step method is useful. First the teacher guides students to review the activity, gathering data on thinking processes and feelings, then the group classifies related, ideas, identifying thinking strategies used. Finally, they evaluate their success, discarding inappropriate strategies, identifying those valuable for future use, and asking promising alternative approaches.

Paired problem solving is another useful strategy.
Reciprocal teaching (Palinscar, Ogle, Jones, Mcarr, & Ransom, 1986).

Self-Evaluation: Guided self-evaluation experiences can be introduced through individual conferences and checklists focusing on thinking process. As students recognize that learning activities in different disciplines are similar, they will begin to transfer learning strategies to new situations.

Strategies for Enhancing Memory and Comprehension (Scifert 1995)

Imagery-dual coding: Reading the information to be remembered and making a picture about it in mind.

Elaborative interrogation-prior knowledge activation: Reading the fact, asking why the fact would be true, and generating an answer.

Acronyms - transformation, organization: Listing words, Listing first letters, Using letters to create, alternative words, Replacing new words until the sentence makes sense, and practice remembering.

Keyword mnemonics- imagery, transformation: Identifying new word pair, finding familiar similar-sounding word, creating an image linking new and familiar words, and practice remembering the image.
Summarizing-attention, relate concepts, transformation: Reading text, identifying main ideas, writing a summary sentence in own words, and combining summary sentences in to a paragraph.

Concept mapping or webbing-identify concepts and relationships, visual representation, dual coding, (elaboration, organization): Reading text, listing important concepts, arranging concepts based on relationships, drawing lines, and labelling lines with the relationship

**Alternative Strategies for Science Teaching and Assessment**

The following are the strategies used in Science teaching effectively:

- Virtual Field Trips, Small group work/ cooperative learning model,
- Case study methods, Resource people in the classroom, Brainstorming,
- Individual projects, Class projects, Oral and visual presentations before the class, Class discussion, Surveys and Polls, Student teaching topic or unit, Problem solving skills, Decision making skills, Posters, pictures, bulletin boards, Lecture, Independent research, Demonstrations, Inventing, Videotape Production, Library research, Competitions, Daily journals, Skits, Teaching other classes, Self-evaluation, Public Presentations, Drawing cartoons, Peer tutoring, mini-conferences, Riddles, Debates, Role play, predict observe Explain (POE), vee diagram, Computer Simulation, Quiz Bowl.
Lodico et al. (1983) hypothesized that for children to maintain the use of a strategy on their own, it is necessary for them to learn the value of the strategy for improving their performance. Furthermore, these researchers hypothesized that children can learn the value of a strategy through training that focuses on monitoring the relationship between strategic behavior and task performance.

Butterfield & Ferretti, 1987; Cavanaugh & Borkowski, 1979; Moynahan, 1978 showed that young children can be trained to monitor their strategic behavior and performance and that this training can enhance their regulation of efficient strategies. Moreover, if people are taught metacognitive awareness concerning the utility and function of a strategy as they are taught the strategy, they are more likely to generalize the strategy to new situations.

However, young children have difficulties spontaneously in regulating and recall, either because they lack knowledge of appropriate sorting strategies, or they know appropriate strategies but lack knowledge of when the strategies should be used, or they are uncertain about the importance of the strategies. Often, young children will rely on less effective, although familiar, rehearsal strategies even when more effective strategies have been demonstrated to them. But, by the age of 10 years, children begin to spontaneously use sorting strategies to facilitate recall.
Even at this age, ability to use sorting strategies may depend on whether the child has sufficient knowledge relevant to the items being recalled (Schneider, 1985).

**Metacognition and Cognitive Strategy Instruction**

Although most individuals of normal intelligence engage in metacognitive regulation when confronted with an effortful cognitive task, some are more metacognitive than others. Those with greater metacognitive abilities tend to be more successful in their cognitive endeavors. Individuals can learn how to regulate better their cognitive activities. Most often, metacognitive instruction occurs within Cognitive Strategy Instruction programs.

Cognitive Strategy Instruction (CSI) is an instructional approach which emphasizes the development of thinking skills and processes as a means to enhance learning. The objective of CSI is to enable all students to become more strategic, self-reliant, flexible, and productive in their learning endeavors (Scheid, 1993). CSI is based on the assumption that there are identifiable cognitive strategies, previously believed to be utilized by only the best and the brightest students, which can be taught to most students (Halpern, 1996). Use of these strategies has been associated with successful learning (Borkowski, Carr, & Pressley, 1987; Garner, 1990).
Metacognition enables students to benefit from instruction (Carr, Kurtz, Schneider, Turner & Borkowski, 1989; Van Zile-Tamsen, 1996) and influences the use and maintenance of cognitive strategies. While there are several approaches to metacognitive instruction, the most effective involve providing the learner with both knowledge of cognitive processes and strategies (to be used as metacognitive knowledge), and experience or practice in using both cognitive and metacognitive strategies and evaluating the outcomes of their efforts (develops metacognitive regulation). Simply providing knowledge without experience or vice versa does not seem to be sufficient for the development of metacognitive control (Livingston, 1996). Strategies should be directly taught to students who have learning problems. The use of explicit teacher modeling is the most effective way to ensure that these students will understand the purpose of a metacognitive strategy, how to use it, and under what circumstances it should be used (Lenz, Ellis, & Scanlon, 1996). Providing students with practice opportunities using the metacognitive strategy is also an important component of metacognitive strategy instruction. It is also very helpful to provide students visual cues of the strategy in the classroom. The strategy can be posted on classroom walls or on a bulletin board; strategies can also be written on individual cue sheets. Some students may also benefit from keeping a notebook that contains all of the strategies that student has learned. This "strategy
notebook” can be organized by concept/skill and could be used by the student as a resource when they are working independently in class or at home. While such cueing is very helpful for students who have learning problems initially, many students begin to internalize the strategy with continued practice.

Metacognitive strategies should be taught after the student has acquired an understanding of the concept/skill. Strategies are not intended to be substitutes for conceptual understanding. Strategies should be implemented after the student has acquired an understanding of the concept/skill. Strategies must be taught, using explicit systematic instruction. Strategies provide students the opportunity to practice independently, which, in turn, builds fluency and mastery of the skill. Strategies can be especially helpful for students who are having difficulty move from the representational level of understanding to the abstract level of understanding because they allow students to practice independently to solve problem at the abstract level. Successful practice provides the repetition which the students often need to establish a working memory of the concept or skill.
3.8. METACOGNITIVE TRAINING STRATEGIES

As criteria for their classification of metacognitive training strategies Osman and Hannafin (1992) used "Training Approach" and "Relationship to lesson content". They describe metacognitive training strategies may be embedded, or integrated within a criterion lesson or strategies may be taught separately, detached from academic subjects. With respect to the role of lesson content, strategies may be dependent on, or independent of content. Content-dependent strategies focus explicitly on concepts that promote learning of particular content. Conversely, content-independent strategies are content-free, general strategies and not specific to particular academic subjects. The four resultant strategies are described below.

Embedded Content-Dependent Strategies

They are useful in understanding unfamiliar lesson material. They are specific strategies that support particular content and as such require explicit manipulation of lesson content and structure.

Embedded Content-Independent Strategies

Embedded content-independent strategies are general strategies that support particular content but are transferable to content of other lessons.
Detached Content-Dependent Strategies

Detached content-dependent strategies are general strategies taught separately from content but meant to be applied within particular content.

Detached Content-Independent Strategies

Detached content-independent strategies are taught separately from content and are generic in nature. As such they support a variety of learning tasks and academic subjects. They help students to manipulate lesson material as well as to develop and maintain learning strategies. These strategies often focus more on procedural than conditional knowledge but the goal is strategy generalization and promotion of independent learning. They provide the greatest potential for transfer.

Research on strategy instruction has been an important part of educational research over two decades. Two recent reviews by Hattie, Briggs and Purdie (1996) and Rosenshine, Meister and Chapman (1996) support the following claims:

i. Strategy instruction typically is regardless of the strategy or instructional method. This means that students usually benefit from instruction (See Pressley & Wharton-McDonald, 1997, for an excellent review).

ii. Strategy instruction appears to be most beneficial for younger students, as well as low-achieving students of all ages. One
reason may be that younger and lower-achieving students presently know a few strategies and therefore have far more room for improvement.

iii. Programs that combine several interrelated strategies are more effective than single-strategy programs (Hattie et al., 1996). One reason may be that no single strategy is enough to bring about a substantial change in learning. A repertoire of four or five strategies, however, may be quite effective in this regard.

iv. Strategy instruction programs that emphasize the role of conditional knowledge enable students to determine when and where to use the newly acquired strategy.

v. Newly acquired strategies do not readily transfer to new tasks or unfamiliar domains. Teachers who incorporate strategy instruction into their classrooms should teach specifically for transfer by using the strategy in a variety of settings (Mayer & Wittrock, 1996). Research also indicates that the more automatic a strategy, the more likely it is to transfer (Cox, 1997).

Hattie et al. (1996) compared rank orderings for approximately 25 different learning strategies across three cultures. Results indicated that a handful of general learning strategies were rated as most important among all cultures. These included in order of importance self-checking, creating
a productive physical environment, goal setting and planning, reviewing and organizing information after learning, summarizing during learning, seeking teacher assistance, and seeking peer assistance. Not surprisingly, most of the commonly used strategy instruction program incorporate these skills (Pressley & Wharton-McDonald, 1997).

Interest in strategy instruction has given rise to the concept of a good strategy user. Pressley, Borkowski, and Schneider (1987) described five characteristics of a good strategy user: (1) a broad repertoire of strategies, (2) metacognitive knowledge about why, when, and where to use strategies, (3) a broad knowledge base, (4) the ability to ignore distractions, and (5) automaticity.

Science Teachers should consider how to sequence strategy instruction. They should limit instruction into 3 to 5 strategies, embed strategy instruction as much as possible, and use peers and tutors whenever possible. Five-step sequence of strategy instruction for science teaching are,

a) Discuss and explain the value of Science Teaching strategies. Students should understand why they are being asked to learn strategies, what instruction will be like, and how they will use them.
b) Introduce only a few Science Teaching strategies. Students can be overwhelmed easily. The best way to teach students general strategies that are useful to them, is to limit the number taught to two or three over an eight- to ten-week period of instruction. This time affords students a chance to acquire the strategy, practice, and become somewhat automatic.

c) Continue practice over an extended period. Plan on six to ten weeks for instruction, modeling, and practice of a new strategy. Periodic follow-ups are helpful to ensure that the strategy is being maintained.

d) Model strategies extensively. Even when students understand why they are learning a strategy and how to use it, they need to see the strategy modeled by a teacher (or other expert). Modeling should include at least two components: how the strategy is used in a variety of settings to accomplish different learning objectives, and why the teacher uses the strategy.

e) Provide feedback to students about strategies (Butler & Winne, 1995). One way for teachers to share their expertise with students is to provide feedback about how, why, and when to use strategies. This information helps students evaluate strategy effectiveness, that is, whether it has made a noticeable improvement on performance or has increased efficiency.
Developing a Strategy Teaching Plan comprises the following steps:

Teaching each strategy first in familiar contexts

Introduce only one new strategy at a time.

Allow the new strategy to be consolidated before introducing the next one.

Giving time for students to see the value of the strategy.

Revising the earlier strategies regularly.

Integrate the new strategy with existing strategies, to decide when and how to use

Allowing students to practice remembering them.

Explicit Metacognitive Strategy Teaching

The following are the procedure of teaching children to use any strategy.

1. Teacher introduces a strategy and make sure they can do the action when they are told to Cue the children to use and practice the strategy

2. Give children the tasks and ask them to use and practice the strategy.

3. Guide them to apply and practice the strategy.

4. Help the children to consolidate the use of the strategy.

5. Help them gradually to transfer the strategy and take control of it.
3.9. METACOGNITIVE INTERVENTIONS STRATEGIES TO ENHANCE COMPETENCY IN TEACHING SCIENCE

Metacognition did not occur as an isolated component in any of the studies. Rather, metacognitive instruction occurred concurrently with instruction in one or more cognitive strategies. In general, interventions in which strategies were taught directly provided more lasting benefit than interventions in which teachers used but did not teach strategies (Billingsley & Wildman, 1990).

Interventions included various combinations of metacognitive knowledge, self-regulation, and/or motivation. Some contained one component; others included many.

3.9.1. EXPLICIT INSTRUCTION

Explicit instruction occurred in the majority of the interventions designed to increase metacognition directly or to induce metacognition indirectly (e.g., Chan et al., 1987; Chan et al., 1990; Hansen & Pearson, cited in Weisberg, 1988; Harris, cited in Harris & Pressley, 1991; Markman, & Gorin, cited in Paris et al., 1991; Paris & Myers, cited in Paris et al., 1991; Paris et al., 1991; Pressley, cited in Harris & Pressley, 1991; Simmonds, 1990; Wong & Jones cited in Billingsley & Wildman, 1990). Direct interventions taught metacognitive components (e.g., the usefulness of a strategy, task demands) explicitly, whereas indirect interventions taught
cognitive strategies (e.g., summarize, predict) explicitly with the assumption that the strategies would, in turn, enhance metacognition.

3.9.2. MODELING

Modeling refers to the process of intentionally demonstrating and describing the component parts of a skill to a novice student. Modeling works because it provides a great deal of explicit information about a skill and raises the novice's expectations that a new skill can be mastered (Schunk, 1991). Peer models are usually the most effective because they are most similar to the individual observing the model. Teacher models are important as well. Often, the teacher is the only person in the classroom who adequately can model a complex procedure.

There are a number of ways to model a new skill other than teacher-directed instruction. One method is reciprocal teaching, in which two to four students work in cooperative learning groups (King, 1992; Palincsar & Brown, 1984). A variety of other methods are described in Schmuck and Schmuck (1992).

Modeling is another instructional feature that occurred in the majority of interventions (e.g., Billingsley & Wildman, 1990; Borkowski, 1992; Chan et al., 1987; Idol & Croll, cited in Billingsley & Wildman, 1990; Palincsar & Brown, cited in Billingsley & Wildman, 1990; Schunk & Rice, study 1 & 2, 1992: Simmonds, 1990). Teachers modeled by
explicitly and overtly 'thinking aloud' the steps for performing a strategy. Simmonds (1990) found that modeling alone without explicit instruction was sufficient to teach students with learning disabilities. Contrary to the finding by Simmonds (1990), Chan et al. (1987) and Schunk and Rice (1992) found modeling-plus-explicit instruction or specific feedback to be more effective than modeling alone for diverse learners.

3.9.3. INTERACTION

A common assumption of metacognitive instruction is that interaction induces the social construction of metacognition (e.g., Palincsar, cited in Billingsley and Wildman, 1990). For example, teacher dialogue that includes how to do a task and providing feedback to students' responses facilitates understanding of the purpose of a task and execution of a strategy (Meichenbaum, cited in Harris & Pressley, 1991). Additionally, discussions between students provide opportunities for metacognitive exchanges and modeling (Palinscar, David, & Winn, 1991).

3.9.4. GUIDED PRACTICE

Chan et al. (1990) concluded that students require adequate time and practice to increase metacognition. Guided practice provides students repeated opportunities to practice procedures of a strategy under teacher supervision.
3.9.5. SYSTEMATIC FEEDBACK

Feedback is an essential part of the modeling process. Feedback refers to explicit information provided to students about the process and products of their work. Feedback provided to students directly from the teacher improves both performance and self-efficacy. Students providing feedback to other students appears to be equally effective in many situations. Self-generated feedback also plays an important role in learning; it enables students to self-regulate their performance without teacher or peer-model assistance (Butler & Winne, 1995).

Cross and Lipson (cited in Paris et al., 1991) concluded that diverse learners require considerable practice with feedback to increase metacognition. In addition, feedback should be specific, carefully planned, and timed (Billingsley & Wildman, 1990).

Several interventions contained feedback for strategy use during comprehension activities (e.g., Harris cited in Harris & Pressley, 1991; Idol & Croll, cited in Billingsley & Wildman, 1990; Malone & Mastropieri, 1992; Palincsar & Brown, cited in Billingsley & Wildman, 1990; Paris et al., cited in Paris et al., 1991; Simmonds, 1990). Feedback specifically linked success in answering questions to strategy use (i.e., strategy-value feedback) (Schunk & Rice, 1992) and included re-explanations and re-instruction as needed (Harris, cited in Harris &

Another common feature was the timing and distribution of feedback. Across interventions, teachers provided feedback at different intervals. Interventions included a range of one to several metacognitive components in various combinations making it difficult to determine which components or combinations of components benefited reading comprehension. Interventions included: self-regulation only (e.g., Chan et al., 1990), a combination of metacognitive knowledge components (e.g., usefulness of strategy, task demands, usefulness of prior knowledge, when to use a strategy) (Rottman & Cross, 1990), or a combination of metacognitive knowledge and self-regulation (e.g., Chan et al., 1987).

3.9.6. INSTRUCTIONAL TIME

Instructional time varied across studies, metacognitive components, and age and diversity of students. The shortest intervention, one that taught self-monitoring using a cross-referencing technique, occurred in one lesson (Chan et al., 1987). The longest intervention, lasting 6 months (Duffy et al., cited in Paris et al., 1991), Three additional longer studies were (a) reciprocal teaching (Palincsar & Brown, cited in Paris et al., 1991) (20 days), (b) a comparison of direct instruction,
reciprocal instruction, and collaborative strategy building (Palincsar, David, Winn, & Stevens 1991) (25 sessions, for 30-40 minutes each), and (c) instruction in a self-questioning strategy to identify main ideas and summarize paragraphs (Wong et al., cited in Weisberg, 1988) (5.5 months).

Metacognition for normally achieving students develops slowly until students are in their teens (Garner & Alexander, cited in Harris & Pressley, 1991), for diverse learners, longer interventions may be more effective and longer lasting than shorter interventions. Ample time may be required for diverse students to experience sufficient modeling, guided practice in a variety of texts, and systematic feedback in order to develop metacognition and independent strategy use.

3.10. METACOGNITIVE ENVIRONMENT IN SCIENCE CLASS ROOM

In the creation of a metacognitive environment in science classroom, teachers monitor and apply their knowledge, deliberately modeling metacognitive behavior to assist students in becoming aware of their own thinking. Metacognitive strategies are already in teachers’ repertoires. We must become alert to these strategies and consciously model them for students in Science Processing and research activities, and provide opportunities for developing metacognitive strategies. Teachers need to focus student attention on how tasks are accomplished. Process
goals, in addition to content goals, must be established and evaluated with students so they discover that understanding and transferring thinking processes improves learning. In this rapidly changing world, the challenge of teaching is to help students develop skills, which will not become obsolete. Metacognitive strategies are essential for the twenty first century. They will enable students to successfully cope with new situations. Teachers and school library media specialists capitalize on their talents as well as access a wealth of resources that will create a metacognitive environment, which fosters the development of good thinkers and lifelong learners.

3.11. ROLE OF SCIENCE TEACHERS

The various roles to be performed by science teachers are,

Life long learner- to learn developments, in science and technology, educational and psychological developments, local/global issues.

Innovator-Sees familiar things, events in new ways, acts as change agent in school and community, is convinced of the need to change if the quality of education and of life is to be improved.

Implementer /developer of curriculum interprets curriculum and translates it into students learning activities

Perceiver of children’s needs /development considering the needs of students when planning the lesson.
**Planner** plans the sequence and emphasis of the lesson.

**Resource manager** selects and mobilizes locally available teaching materials, equipments, facilities.

**Facilitator of learning** facilitates the growth of scientific literacy through development of science process skills.

**Interpreter and communicator**- Interprets and communicates to students the concepts, processes, and philosophy of science as stated in the curriculum.

**Supervisor of children's growth and development** - supervises activities and provide opportunities for intellectual and physical growth of children.

**Promoter** of Values, attitudes, social responsibility

**Evaluator of learning outcomes**- assesses the cognitive, affective, and psychomotor leanings of students in science. Constructs tests, devises instruments and procedures for evaluating the affective domain and psychomotor domain.

**Effective member in community development**- participates in projects that develop and improve the community, links science and school in the community.
3.12. DESIRABLE COMPETENCIES AND SKILLS FOR SCIENCE TEACHERS

In terms of science teaching competencies it would be desirable to specifically identify the requisite skills for each area mentioned below.

- Science processing skills
- Instructional skills
- Information processing
- Decision making
- Creativity
- Confidence in science concepts
- Relates new concepts to prior science knowledge that the students posses.
- Encourages Students to be more curious about natural phenomena.
- Joins with pupils in solving problems and trying out different activities.
- Listens to children’s ideas intently.
- Relates science concepts to daily life situations.
- Encourages students to relate science concepts that they learn in school to solve community problems.
- Appreciates the role that science plays in solving community problems.
• Help to link science with other subjects.

• Reinforces student’s answers to motivate them to ask questions relevant to their observations.

• Encourages students to initiate their own science projects related to what they learn.

• Handles pupils of different scientific ability

• Communicates effectively with in the level of comprehension of the children.

• Uses suitable resources for every science learning activity

• Organizes for desired interaction in science activities.

• Assesses pupils performances in science using different modes of evaluation

• Adjusts to the situation to get the desired or possible learning outcomes.

3.12.1. SCIENCE PROCESS SKILLS

It is essential that science teachers acquire and be able to demonstrate science process skills. They must have a clear systemic view of how scientific capabilities may be developed. They must also have a clear cut and systematic view of teaching competence in conducting, activities for the development of these skills.
One of the aims of science teaching and learning is to develop science process skills among the teachers. It consists of basic skills and integrated skills. Basic skills are

- **Observing**—"identify and name/find out properties of an object or situation by using their senses."
- **Space/Time relationship**—"Construct drawings of common 3-dimensional shapes"
- **Classifying**—"identify and name observable properties of objects which could be used to classify the objects".
- **Using Numbers**—"State and apply rules for expressing the mean of a set numbers, rates as ratios, and the decimal equivalents of ratios."
- **Measuring**—"Demonstrate the use of simple measuring instruments to measure length, mass, and time.
- **Communicating**—"Describe the properties of an object with sufficient details so that another person can identify it."
- **Predicting**—"State predictions by interpolating between observed events or extrapolating beyond the range of observe and events."
- **Inferring**—"Identify inferences that should be accepted, rejected or modified on the basis of additional observations." Integrated skills make use of basic skills in the development of more sophisticated processes of science.
• Formulating hypothesis-“Construct a hypothesis that is a generalization of observations or of inferences.

• Controlling variables-“Identify and name variables which were not held constant in the description of an investigation, although they varied in the same way in all treatments or were randomized.”

• Interpreting data-“Describe certain kinds of data, using the mean, median, and range, construct predictions, inferences, or hypotheses from this information.”

• Defining operationally-“Construct an operational definition which adequately describes a procedure, concept, object, or property of an object in the context in which it is used.”

• Experimenting-“Construct a question to be answered, construct a test that will provide data to answer the question identify variables to be controlled, construct operational definitions, demonstrate the test and collect and interpret data from a given set of observations. Construct a report of the experiment.”

3.12.2. INSTRUCTIONAL SKILLS

- Using variety of resources
- Using, improving, developing of teaching aids.
- Designing activities
- Effective utilization of Laboratory and instruments.
- Stimulate/arouse students interests
- Bringing in real life to class and vice-versa.

3.12.3. INFORMATION PROCESSING SKILLS

- Identify, locate and Utilize information
- Classify, analyse and Utilize relevant information.
- Search for ways to understand scientific information from primary science
- Always update oneself on scientific and technological information

3.12.4. DECISION MAKING SKILLS

- Select reliable information and clarify values, ethics.
- Identify alternative.
- Predict the consequences of each alternative.
- Order the alternative
- Take actions consistent with the stated values.
- Accept possible consequences of the actions taken.

List of competencies stated by the Directorate of Teacher Education and Research Training, Government of Tamilnadu and Pondicherry for teaching science are,

a) The student teacher is conversant with the contextual competencies of science.
b) The student teacher will be familiar with conceptual competencies.

c) The student teacher is through with the content competencies of science in standards 1-8.

d) The student Teacher is well versed with transactional competencies.

e) The student teacher is thorough with the competencies to develop teaching learning materials.

f) The student teacher is well versed with evaluation competencies.

g) The student teacher understands competencies related to working with parents, community and other agencies.

3.12.5. TRAINING IN INSTRUCTIONAL COMPETENCIES

Lesson Preparation

A major task of the science teacher is lesson preparation. A successful performance of this task demands the use of skill which the teacher is expected to learn. Already the trainees aware of the preparation of the lesson plan they were suggested to follow the steps given below.

a) Selecting a topic from a real life situation
b) Stating objectives of the lesson.

c) Selecting strategies and resources to use in teaching the lesson.

d) Writing a plan for a science lesson.

e) From the list of teacher competencies/skills and which of them the teacher uses to pursue the lesson.
f) From the list of teacher role which role the teacher is going to perform in this topic for teaching.

The objectives of each lesson must be stated explicitly in terms of learning outcomes. Lesson objectives can be stated in terms of competencies /skills (eg. Science Process skills like observe, predict, hypothesis, infer etc). Lesson objectives can be stated so as to include the teaching strategies (Eg. to design an experiment, project, etc). The objectives may be cognitive, affective, or psychomotor.

Cognitive Objectives: development and refinement of knowledge, and acquire of knowledge.

Affective Objectives: which concern with feelings, interests, appreciations, attitudes, and values.

Psychomotor Objectives: those intended to develop and refine action, motion and behaviors.

To include metacognitive activities, the investigator asked the Trainees to Self-question about the students needs while preparation of a lesson. The sample questions are,

a) How did I make my strategies more suitable to students?

b) How did I provide for the development of skills in students?

c) How did I provide for the development of thinking skills to students?
d) How did I provide for attitude and value development of students?

e) What are the skills do I need to do all of the above?

f) What role do I perform in taking in to consideration numbers a-d?

Discussions on the following headings were conducted by the investigator and the trainees, for the selection and use of strategies:

- What strategies and resources you will use in teaching lesson for chosen topic?

- What strategies fit the objectives and resources?

- Focus on strategies that develop science process skills, decision making skills, information processing skills, attitudes, values, whenever possible.

- Are the strategies you have chosen for your lesson suitable? How can you tell?

- Are the resources to be used with the strategies are appropriate?

- Focus on resources available with in community

- Resources include teaching aids, equipments, and references etc.

- What are the skills are needed to choose the appropriate strategies and resources for your lesson?

- What role is performed while selecting a particular strategy and a resource?
The trainees write the objectives, strategies, and resources identified and write a lesson plan and arrange them as follows with all their details.

**Topic:**

**Objectives:**

**Concepts/sub concepts**

**Procedure/strategy**

**Methodology**

**Resources:**

The trainees consider the following strategies while selecting the resources to teach in the science classroom, which refers to all the materials to be used in teaching the lesson. It includes charts, maps, instruments, equipments, chemicals and other consumable materials, films, videos, tapes, transparencies, and reference.

- The age level of the students, for which the resources will be used.
- The sufficiency of the resources to motivate and maintain the interests of the students.
- Whether the use of the resources will help in developing the science ideas and objectives aimed for,
- Whether resources will be easy enough to use under the classroom conditions available in the school.
Weather it be possible to allow students to handle and operate/manipulate/use these resources.

Lesson Presentation

Use of Motivation: During presentation, engage the students interest from beginning to end of the class. Continuous motivation should be given throughout activities, rewards, reinforcement, encouragements, use of equipment, teaching aids, stimulating verbal interaction in class. Trainees used motivational Strategies in motivating students to perform activities and tasks relevant to learning.

Supervising Students Activities: The science class room should always be with lot of activities either by teacher or by students or both. Science teacher should know how to supervise students activities in the science classroom.

- Provide activities for learning.
- Safety and well being of the students are provided.
- Materials and equipments are correctly used to prevent breakage and wastage.

The following activities are suggested by the investigator.

- Briefly describe the activities that students will perform during the lesson.
- State the reasons for choosing the activities.
• Identify the competencies/skills needed to supervise student performance on the activities.

• The roles performed by the teacher when supervising the student activities.

**Interactive Session:** Conducted interactive session in the classroom with the students by the trainees, using the motivational strategies such as self-views, self-perceptions, reward, self-reinforcement. The Trainees conducted Interactive sessions with students are largely verbal. Both students and teacher talk, exchange ideas, views, refine, modify, reinforce, and restate each other idea. Science ideas are interacted by teacher and students. Teacher tactfully and affectionately encourages the shy and reticent students to share their ideas. No single person monopolies the session. A summary of main points discussed can reinforce students learning. A resource person can be invited to share his/her expertise on the subject.

**Metacognitive activity:** The trainees involved in **self–reflection** as follows

• What are the scientific ideas are expected to be brought out in the interactive session?

• What are the procedural matters concerning the strategy used, would need further discussion?
• What kind of learning outcomes is to be expected from the interactive session?
• What are the skills to be developed in conducting the interactive session on the chosen topic?
• What are the roles performed by the teacher in carrying out the interactive sessions on the chosen topic?

3.12.6. EXPERIMENTAL SESSION

Pre-experimental session

**Peer Discussion:** Discussion among trainees is conducted under the guidance of investigator. Questions prepared in advance will help to start discussion. A discussion is meant to stimulate thinking on scientific attitudes, values, and ethics.

**Experimental Session:** The trainees need to develop rational thinking, scientific methods of analysis and arriving. They need to apply these in their real life situations with full awareness of short and long term consequences.

**Strategies suggested:** Observation, inquiry, predicting, hypothesis forming, inferring, gathering data, skill in handling apparatus, reporting are strategies suggested to the trainees.
Competencies and skills most needed during the experimental session are,

**Science process skills:** communicating, interpreting data and making conclusion.

**Information processing skills:** identifying, locating and utilizing information, classifying, analyzing, and utilizing relevant information searching for ways to understand scientific information from primary sources. Always update oneself on scientific and technological information, as well as information in other areas.

**Decision making skills:** Selecting reliable information and classifying values, ethics, Identifying alternatives, Predicting the consequences of each alternative, Weighing the pros and cons of each alternative ordering the alternative. Taking actions consistent with the stated values. Accepting possible consequences of the actions taken.

**Post-experimental Session (Reflective Thinking Session):** Upon completion of the experimental session, reflective thinking session is required as a follow up activity. It is assumed that the teacher trainee now have acquired competencies and skills required for development of scientific attitudes, values and ethics. The trainees were asked to do some reflective thinking on the following metacognitive activities:
What are the competencies required, from the beginning to the end of experimental session?

To what extent does the experimental session, help you to develop scientific attitudes, values, and ethics?

At this point the investigator may need to provide explanations and examples concerning such competencies and skills. Moreover, the trainees may need to be given more exercise to practice such competencies and skills.

The teacher trainees should discuss among them selves with guidance of teacher educator about strategies/activities to be used in real classrooms in order to bring about the development of scientific attitudes, values, and ethics.

Present after discussion and reflection, a view of the interplay of competencies and skills needed to develop the scientific attitudes, values.

Planning and development of strategies/activities for children.

Relate the competencies and skills to strategies and activities with scientific attitudes,

Acquire skills in developing feelings of concern and social responsibility in children.
3.12.7. EVALUATION OF CLASS ROOM STUDENTS

The trainees were asked to evaluate students through observations like what to observe (event), whom to observe (individuals), when to observe (short period), and how to observe (check list notes). The following scientific attitudes of the students were observed

**Rationale**

Always provide reasons or evidence to support ideas.

Judgment is usually based on information.

**Open-minded**

Accept other people’s idea that are different from one self’s.

Willing to change one’s idea if more information is provided.

Willing to listen to others.

**Honest**

Sincerity of observation, accuracy, commitment all combine together to indicate the honesty of effort or activity.

**Social responsibility**

Think collectively (always take into consideration the factors concerning community or group).

Take action (if need be) for the benefit of community/society/group.

Concern for others.
Belief and apply process of science

Recognize the value and importance of the process of science (scientific method).

Apply process of science in daily life (tackle problems systematically).

The trainees were asked to observe the student activities in the areas of Field work, Science process skills, Teaching strategies, Experimentation, Group discussion, Assignment, Project, and Follow up activities. Based on the above observations a check list was prepared in terms of students participation.

Evaluation of Instructional methods and behaviors in science Classroom: The goal of pre-service teacher training is to have the trainee teachers gain competencies and skills in teaching. An evaluation of the classroom practices is a way to investigate the teachers competency and skills as applied in teaching. This could be done by peer-group teaching, teaching practices and teaching demonstrations. Responses could be obtained from the teacher trainers, peers, classroom students and even from the trainee through self-evaluation.

Evaluation of the trainees classroom practices can be made by using a checklist on types of instructional methods applied by the trainee
together with observation questionnaires on teachers and students behaviors in the science classroom. The types of instructional methods used are Question – answer methods, Lecture method to the whole class followed by questions from individual students. All students do the assignment, The class is divided in to small groups who work together on same assignments or different assignments including practical/laboratory work, Presentation of audio-visual materials to the class, and The whole class goes on a field trip or excursions in connection with the science programme visit industries, botanical gardens, zoological parks, or scientific important places.

**Evaluation of Teacher behaviours in Science Classroom:** The investigator has noted the following behaviors of the trainees in the science classroom.

- At the start of each science lesson, the teacher reminds the students about the work they covered and concepts and ideas learned during the previous lessons.
- At the end of science lesson the teacher gives a summary of what was learned in the lesson.
- The students are allowed to make their own choice of science topics to study.
- The teacher uses students ideas and suggestions when planning science lessons
• The teacher does demonstrations to help explaining scientific ideas.
• The teacher makes science lessons interesting for students.
• The science teacher helps students who have difficulties in learning science.
• The teacher explains how the science that the student are learning relates to their own life.
• The teacher discusses possible careers in science with the students.
• When students do experiments, the teacher provides them with problems to solve and then leaves students to work out their own methods and solutions.

**Student’s behavior in the Science Classroom:** The trainees were asked to note the behavior of the students as below.

• During science lessons the students copy teachers notes from the blackboard.
• For science home work students report their laboratory and practical work.
• Students have tests on what they have learned in science.
• Students do field work outside the classroom as part of their science lessons.
• Students do practical work as part of their science lessons.
• The science class is divided into small groups of students to do practical work.
- When students perform experiments, the teacher gives instructions about what to do.
- When students perform an experiment, they use a practical book or other written instructions on how to perform it.
- In their practical work, students identify their own problems and then the teacher helps them to plan experiments to solve problems.
- In their practical work, students identify their own problems and work out their own methods to investigate the problems.

3.13. MOTIVATION

The International Encyclopedia of Education-vol.: 6 defines motivation as the term referring to the causes for the initiation, continuation, (or cessation) and direction of behavior. The intensity and direction of motivation may vary from person to person. Motivation is a process whereby goal-directed effort is initiated and sustained. Research on the role of motivational beliefs in learning has mushroomed over the past decade (Pintrich & Schunk, 1996; Stipek, 1993). Researchers once believed that motivation had little impact on how students learned. This view has changed dramatically, in favor of the view that motivation not only prepares a student to learn, but changes the learning process itself. A number of different types of motivational beliefs have been studied recently, including self-efficacy (Bandura, 1997), attributions (Weiner,
1986), goal orientations (Dweck & Leggett, 1988), intrinsic motivation (Kohn, 1993), hope (Synder, 1995) and perceived control (Deci & Ryan, 1987).

**Factors affecting motivation:** There are several factors affecting motivation. They consist of Goals, Incentives, Vim and Vigor, Mobilizing the will-to-work, Quality of environment, Drive for self-realization, and Anxiety.

**Dimensions of Motivations:** The most considered ten dimensions of motivation are, Needs, Physiological needs: food, water, air, rest, house, work, Security, Emotional and mental requirements, Love, affection, pity, sympathy etc., Social needs; establish oneself in society, Aesthetic needs, Needs of self-actualization, Drives, and Incentives.

**Classifications of Motivation:** Based on physiological needs motivation can be classified as,

Primary physiological Motives: Hunger, thirst, pain, sex, impulse etc.

Secondary Psychological Motives: Social status, approbation, authority over others, self-respect, self-importance, social identification, security

**Techniques of Motivation in Classroom Teaching** are Reward and punishment, Praise and insult, Competition, Knowledge of progress, Knowledge of achievement, Novelty, Audio-Visual Apparatus, Interest, and Self-Importance.
3.14. THEORIES OF MOTIVATION

Instinct Approaches to Motivation

William McDougall 1908, Bernard, 1924 theory says that motivation is the result of an inborn pattern of behavior that is biologically determined. Drive reduction approaches (Hull, 1943) theory claims that drives are produced to obtain our basic biological requirements. Drive a motivational tension, or arousal that energizes behavior in order to fulfill a need. Homeostasis theory is the process by which an organism tries to maintain an internal biological balance or steady state. Arousal approaches by Berlynem, 1967, Brehm & self, 1989, try to maintain certain levels of stimulation and activity, increasing or reducing them as necessary. People vary widely in the optimal level of arousal (Mineka & Henderson, 1985: Babbitt, Rowland, &Franken, 1990, Stacy, Newcomb & Bentler, 1991). Incentive Approaches is the theory explaining motivation in terms of external stimuli which acts as a reward. This reward in motivational terms is incentive.

Cognitive Approaches to Motivation

Two kinds of cognitions underlie our behavior, the first is our expectation that a behavior will cause us to reach particular goal, and the second is our understanding of the value of that goal to us Tolman, 1959. Two cognitive approaches to motivation are,
Intrinsic Motivation: Motivation by which people participate in an activity for their own enjoyment and not for the reward it will get them.

Extrinsic motivation: Motivation by which people participate in an activity for a tangible reward.

According to research on the two types of motivation we are more apt to persevere, work harder, and produce work of higher quality when motivation for a task is intrinsic rather than extrinsic Lepper & Greene, 1983, Deci & Ryan, 1985, Harackiewicz & elliot, 1993.

Maslow’s Hierarchy: Maslow’s model, 1970 considers different motivational needs to be ordered in a hierarchy and it suggests before more sophisticated higher order needs can be met certain primary needs must be satisfied. The model can be conceptualized as a pyramid in which the more basic need to be activated and thereby guide a person’s behavior the more basic needs in the hierarchy must be first. The more basic lower order needs are described as primary drives: e.g. ware, food, sleep, sex. Safety needs come next in the hierarchy. Physiological and safety needs compose the lower-order needs.

Only when basic lower order needs of a person are met then a person consider higher order needs, such as need for love and sense of belonging, esteem, self actualization. Self actualization is a state of self fulfillment in which people realize their highest potential.
Maslow’s Hierarchy of Needs

Need for achievement: (McClelland et al., m 1953) theory states that satisfaction is obtained by striving for and attaining a level of excellence.

Need for affiliation: According to Wong & Csikszentmihalyi, 1991, it is a need to establish and maintain relationships with other people, a desire to maintain or reinstate friendships and show concern over being rejected by friends.

Need for Power: Winter states this as a tendency want to make an impression or have an impact on others in order to be seen as a powerful individual.
3.15. ROLE OF MOTIVATION IN EDUCATION

An important role of motivation is to contribute to the maintenance of positive self-views and perception of self-efficacy and personal control that underlie the ability to change negative attitudes and orientation towards science learning. Support for this position can be found in variety of theoretical perspectives. Some of them are Competence motivation, Self-efficacy theory, and Attribution theory.

Competence Motivation

White's (1959) defined competence as an individual's capacity to interact effectively with his environment. He argued that there is a competence or "effectence" motivation that is directed, selective, and persistent and which satisfies an intrinsic need to deal with the environment. A feeling of efficacy is the subjective and affective result and also the aim of competence motivation. White contended that it is this feeling of efficacy, rather than learning that comes as its consequence, which can lead to continuing interest. The intrinsic need being met by competence motivation is to bring environmental factors under greater control and thus enable an individual to become more self-determining. Competency motivation serves the functions of not only producing feelings of efficacy but also directing attention and organizing actions that will result in effective interactions with the environment. Perceived competence is defined as a dynamic, multidimensional construct.
involving perceptions of one’s competence in cognitive, social, and physical domains (Harter, 1982). Self-worth arises out of perceptions of competence and control (Harter) the concept of the self and feelings of self-worth as these relate to perceived control and competency, and as an integrating self system in motivation and learning. Thomas (1980) says, what motivates learners to seek out or avoid learning activities is their perceptions of their competence, their perceptions of value or rewards associated with successful task completions, and their perceptions of the extent to which their effort will lead to success.

Self-efficacy

Self-efficacy refers to the degree to which an individual possesses confidence in his or her ability to achieve a specific goal. High efficacy in one setting does not guarantee high efficacy in another. Within a specific domain, however, high self-efficacy positively affects engagement, persistence, goal setting and various aspects of performance such as the type and amount of strategies used and the degree to which students monitor their learning (Schunk, 1989)

Bandura’s (1978, 1982, 1986) self efficacy theory also emphasize the role of perceived competence (Self-competence) and perceived self-control in motivation and performance.
Bandura has argued that for individuals to have a strong sense of self-control, it is necessary for them to develop a range of competencies, self-perceptions of efficacy, and self-regulatory capabilities that can increase their self-directedness. He defines perceived self-efficacy as personal judgments about how well we can execute the courses of actions that are required to handle particular situations. Judgments of self-efficacy are said to be strongly affected by individuals’ perceptions of their abilities to exercise adequate control over their actions.

Research also indicates that teacher efficacy plays an important role in the classroom (Calderhead, 1996). Teachers with higher levels of teaching efficacy set broader curricular goals, provide greater student challenge, and invest more time helping students (Bandura, 1993; Woolfolk & Hoy, 1990). Highly efficacious teachers plan better by using their knowledge about course content, general pedagogy and student development. This is often referred to as pedagogical content knowledge (van Driel, Verloop, & de Vos, 1998).

Attributions

Attributions are causal interpretations students provide themselves to explain their academic success and failure. For example, students who struggle in attribute their failure to low ability rather than lack of relevant knowledge, strategies, or practice. Attributional responses vary along
three causal dimensions (Weiner, 1986), including locus of control (i.e.,
internal vs. external causes), stability (i.e., short vs. longstanding effects),
and controllability (i.e., controllable vs. uncontrollable). Different
attributions elicit a variety of distinct emotions in learners. For example,
attributing failure to a teacher (i.e., an uncontrollable, external, unstable
cause) is less debilitating than attributing failure to low ability (i.e., an
uncontrollable, internal, stable cause). Theory assumes that the underlying
motivator of human behavior is the search for the casual understanding of
failure

Clifford (1984) has recently presented a theory of constructive
failure. It states that the failure is more likely to produce constructive
effects if students have high expectations for control. She also argues that
more attention should be given to encouraging strategy explanation for
failure. The argument is based on the rational that strategy explanation
can turn failure outcomes in to problem solving situations and students
can focus on finding more effective strategies rather than focusing
negative implications of failure. By increasing students knowledge and
awareness of strategies (metacognitive level of training) and training them
to discriminate between strategy, effort, and ability attributions,
perceptions of control can be increased.
A number of studies have examined the kind of attributions that students make and why they make them. One of the most important findings from this literature is that different students make very different kinds of attributions. Some of these differences are gender related. For example, females in and science settings are much more likely to attribute failure to ability (rather than effort) compared to males (Stipek, 1993). However, all students make frequent ability-related attributions. A review by Peterson (1990) found that negative attribution styles (e.g., attributing failure to ability and teachers) are related to low grades, less help seeking, vaguer goals, poorer use of learning strategies, and lower performance expectations. Fortunately, when students are aware of their attributions and guided by knowledgeable teachers, negative attributions can be changed.

Motivational Beliefs

Motivational beliefs refer to personal beliefs about:

- One's general competency (Borkowski, 1992; Rottman & Cross, 1990, also referred to as self-efficacy, self-esteem, and self-worth.

- One's competency to perform specific tasks, such as applying strategies and achieving goals (Schunk & Rice, 1992; Johnston & Winograd, 1985).

- One's ability to control or influence academic outcomes (Garner,

- The causes and extent of academic successes and failures (Johnston & Winograd, 1985; Paris et al., 1991).

Positive Motivational Beliefs: Positive motivational beliefs are common among persons described as (a) self-regulated learners, (b) strategic readers, (c) achieving students, and (d) successful students. The normally achieving students tend to hold one or more of the following beliefs: I can control or influence academic outcomes (Weiner, cited in Paris, et al., 1991); my academic successes and failures are caused by variables within my control, such as effort (Borkowski, 1992; Borkowski, Carr, Rellinger, & Pressley, cited in Paris et al., 1991; Diener & Dweck, cited in Johnston & Winograd, 1985); and, I am capable of accomplishing reading tasks (Harter & Connell; Weiner, cited in Paris et al., 1991). The latter belief may stem from knowledge of multiple strategies for learning effectively (Paris et al., 1991). Science teacher should have positive motivational belief to become a successful teacher.

Negative Motivational Beliefs: Negative motivational beliefs are common among (a) persons described as passive failures or helpless students, and (b) persons with reading difficulties, learning disabilities,
poor comprehension skills, low self-worth, and a history of academic failure. These diverse learners tend to hold one or more of the following beliefs: I have little or no ability to accomplish reading tasks (Butkowsky & Willows; Lict & Kistner, cited in Schunk & Rice, 1992); I have little or no control over academic outcomes (Abramson, Seligman, & Teasdale, cited in Johnston & Winograd, 1985; Butkowsky & Willows; Lict & Kistner, cited in Schunk & Rice, 1992; Garner, cited in Paris et al., 1991); I have little confidence that I will benefit from using reading strategies (Garner, cited in Paris et al., 1991; Schunk & Rice, 1992); and, I have low expectations that I will successfully complete given tasks (Johnston & Winograd, 1985; Paris, et al., 1991). The latter belief may stem from inaccurate perceptions of the extent of academic successes and failures (Johnston & Winograd, 1985).

**Motivational Beliefs and Self-Regulation**

**Borkowski (1992)** provides a theoretical explanation for the relation between motivational beliefs and self-regulation in his theory of metacognition. He argues that motivational beliefs develop over time as a function of how "refined" one becomes in their strategic and executive processing. As processes become refined, positive motivational beliefs develop, including self-competency, strategic awareness, and attributing success to effort. When processes do not become refined, negative motivational beliefs develop, including feelings of in competency, and
attributing success to luck. Borkowski also argues that motivational beliefs influence whether strategies will be selected and maintained in the future. Self-regulatory attempts that have resulted in feelings of self-competency are maintained while those that have resulted in feelings of in competency are avoided.

The relation between motivational beliefs and self-regulation was investigated within the context of strategy instruction in two experimental studies (Borkowski, Weyhing, & Carr, cited in Paris et al., 1991; Schunk & Rice, 1992) and one quasi-experimental study (Borkowski, Carr, Rellinger, & Pressley, cited in Paris et al., 1991). Self-regulation outcomes associated with changes in motivational beliefs.

3.16. PHYSIOLOGICAL ASPECTS OF MOTIVATION

Limbic association area in brain concern with behavior, emotion, and motivation. The behavior of animals and human beings is mostly affected by two opposing responding systems, which involves hypothalamus and other structures of limbic system. These systems are concerned with affective nature of sensations, where sensations are pleasant or painful. These two qualities are called the reward/satisfaction and punishment/aversion or avoidance. Two centers in hypothalamus involved are reward center and punishment center. Reward and punishment centers present in hypothalamus and other structures in limbic system are required for motivation.
**Reward Center**

Electrical stimulation of medial fore brain bundle and ventromedial nucleus of hypothalamus in animals pleases or satisfies the animals, these areas are called reward centers. Less potent reward centers which perhaps secondary to the major ones in the hypothalamus are found in the septum, the amygdale, certain areas of the thalamus and basal ganglia, and extending downward into the basal tegmentum of the mesencephalon.

**Punishment center**

The electrical stimulation of posterior and lateral nuclei of hypothalamus leads to pain, fear, defense escape reactions and other elements of punishment centers. Limbic System refers to neuronal circuit that control emotional and motivational drives. It is also called visceral brain neutral circuit involving hippocampus for emotion or experience. Hypothalamus and limbic system are intimately concerned with emotional expression.

Punishment areas located in the Central gray matter around aqueduct of sylvius in the mesencephalon, and extending upward in to the periventricular zones of the hypothalamus and thalamus. Less potent punishment areas are found in some locations in the amygdale and the
hippocampus, mid brain extending up to periventricular zone of hypothalamus and thalamus.

Importance of reward and punishment in behavior are useful to regulate our bodily activities, drives aversions and motivations. If it is rewarding we continue to do it. If it is punishment we stop doing it. They help in learning and memory. Simulation periventricular zone give rise to rage reaction. Placidity and tameness behavior pattern occurs if reward centers are stimulated.

**Emotional Centers and Intelligence**

The Orbito Frontal areas (orbito insular lingualargyrus) especially the orbital surfaces are concerned with emotions and behavior. Lateral areas are concerned with intellectual capacity. Other areas of cerebral cortex are concerned with learning and development of memory pattern.

**Reinforcement**

Negative Reinforcement can be elicited from lateral midbrain and posterolateral diencephalons extending into ventrolateral and ventral thalamus. Positive reinforcement is elicited from whole of the limbic system and most of the medial fore brain bundle sweeping from septum through medial hypothalamus into medial midbrain reticular formation. Periaqueductal grey mechanisms for central reinforcement relate closely to mechanisms concerned with motivation.
Affective Attitudes

Olfactory signal have importance in determining affective attitudes and behavior. Olfactory memory is powerful in commanding attention. Complex perceptions and perceptual memory project to Amygdala. Amygdala helps in decision making by generating command executed through hypothalamus and limbic projections to posterior dien-cephalon and midbrain that control approach and avoidance behaviors.

Levels of Behaviors

Limbic system involves three levels of behavior Drives, Emotions, Volitional or goal directed behaviour. The amygdale, prepyriform cortex and septal nuclei constitute the rhinal system concerned with the expression of drive. Amygdala and Hippocampal circuits from the paleal system involved in emotional behaviour. Hypothalamic and midbrain structures are involved in volitional or goal directed behaviour. Amygdala, prepyriform cortex and septal nuclei constitute retinal system concerned with drive Amygdala and hippocampal circuits form paleal system involved in emotional behaviour.

3.17. MOTIVATIONAL STRATEGIES

In order for learners to accept responsibility for their own learning, they must be motivated as well as possess the skills and abilities to actively engage appropriate metacognitive, cognitive, and affective strategies. Self-control of learning is the motivation to learn. We need to
understand what makes up the skills and will to maintain motivation and use appropriate strategies. The self-controlled and self-motivated learner is one who can plan, regulate, and evaluate his or her own skills and strategies. Strategic behaviour involves intentionality and self-control. They combine skill and will to accomplish a goal (Paris et al., 1985)

Motivation and Strategy Use in the Self-Regulation Process

Motivation and strategies each contribute to academic success at all age levels. Motivational variables are referred often as the will component of learning; strategies are referred as the skill component. Students need both the will and the skill to succeed in science courses. Most of the students struggle initially in science because they lack, the will and the skill which contribute to academic learning in several ways. One way is through a reciprocal interchange between will (i.e., self-efficacy) and skill (i.e., strategy instruction) components. As self-efficacy increases, students are more apt to use strategies. As strategy instruction increases, students become more self-efficacious. A second way is through a reciprocal interchange between will components. For example, higher self-efficacy is related to adaptive attribution responses such as increased effort and strategy use. A third way is through a reciprocal interchange between skill components. For example, acquisition of new knowledge typically increases the efficiency of strategy use. Students who continue using strategies are motivated by a sense of the importance
Components of Metacognition, Motivation and Competencies in Teaching Science

**METACOGNITION**
- Meta knowledge, Meta memory, Advanced organizer, Debugging, Selective encoding, Checking, Test debriefing, Selective attention

**MOTIVATION**
- Self Appraisal, Self talk, Self Evaluation, Self Management,
- Self control, Goals, Attention, Self monitoring, Self regulation, Reflection in action,
- Interest, Self-efficacy, Self Esteem, Self assessment, Self confidence

**COMPETENCIES IN TEACHING SCIENCE**
- Observation, Classification, Interpretation, Inferring, Predicting, Selection, Experimenting, Communication, Measuring, Facilitation, Decision making, Information processing, Instructing
of being strategic. Students who avoid using strategies are motivated by a desire to avoid failure. According to Paris, Wasik, and Turner (1991), students engage in avoidance strategies that lead to short-term success, require minimal effort, and offer protection against loss of self-esteem. Examples of strategies for avoiding failure include: withdrawal of participation; feigning interest or involvement; shifting blame from self to external factors such as noise, illness, task difficulty, bad luck.

**Self-control**

*Watkins 1984* stated that, if students perceive they have control over their own learning, they are more likely to use deep information processing approaches in which they focus on the content as a whole, try to see connections between the parts, and actively think about the structure information. When a lack of control is perceived the students are most likely to view learning tasks as memory tasks. Stipek and Weisz (1981) have argued that perceptions of personal control are essential for the development of a sense of competence following successful mastery attempts. Increasing students perceptions of personal control can increase motivation and achievement. It has also found that strategies for increasing perceptions of control also increases judgments of self-efficacy-judgments that positively affect motivation and achievement (Bandura, 1982, Bower, 1981, Schunk, 1984).
Persons with developed senses of personal control and competency are more inclined to use previously learned skills and strategies in new learning situations (Lefcourt, 1976, Paris et al., 1983, 1985, Wang, 1983, Ryan et al., 1983). The importance of self perceptions and self-evaluations (including self-efficacy, self-competence, Locus of control, self-responsibility) is in fostering continuing motivation for learning new skills.

Interventions that have proven successful in modifying a sense of personal control and enhancing achievement in Wang (1983) research include direct instruction in self-management skills (Planning, information organization, goal setting, scheduling, and time management) and providing opportunities for self-managed learning. Self-control of learning, is students development of metacognitive skills for planning, monitoring, regulating, and evaluating learning activities. Baird and White (1982) stated that self-control during learning requires learners to engage in self-evaluations of understanding, self-evaluation of competence, and a variety of other metacognitive activities including being awareness of nature of the process of learning, personnel learning styles, conscious self monitoring and decision making during learning. Metacognitive skills provide the basic structure for the development of positive self-control. Motivational strategies would include techniques for marinating positive
self evaluations of understanding (self talk, and imagery to positive self-views.) and strategies for self management, and self-control.