CHAPTER 1       CONCEPTUAL FRAME WORK

Good teaching is forever being on the cutting edge of a child’s competence.

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1.1 Backdrop of the study

Education is the most powerful instrument whose effective use requires the strength of will, dedicated work and sacrifice. As this instrument is in the hands of teachers in the present scenario, they must possess the skill of evolution of innovative strategies besides the strength of will, dedication and sacrifice. Education intends to develop desirable habits, skills and attitudes which make an individual a good citizen. The quality of education of students depends upon the competence, dedication and quality of school teachers. It is not brick and mortar of the classroom, but the dialogues rapport and interactions supported by deeds, between the learners and the teachers, all the time developing within its four walls can make or mar the destiny of the youngsters and in turn that of the nation. Being a teacher is to be a change agent transforming ideas into ideals and ideals into institutions which may spread the light of knowledge and wisdom into eternity. A competent and committed teacher is in demand for today’s revolutionary era. Teacher commitment has been identified as one of the most crucial factors for the success of the education and schools which are closely associated with their work performance.

Developing teaching competence in teaching practice has been viewed as an important component of teacher education in some countries in the developed world. Tisher (1987), focusing on teacher education in Australia, claimed that: School experiences are extremely important, practical, satisfying component of pre-service education…student teachers say they gain a lot from it; that it is the
most realistic aspect of their courses, helps reduce their anxiety about teaching, and fosters their practical teaching skills (Tisher, 1987).

Teaching practice is one of the most influential components in the preparation of B.Ed trainees (Clark et al., 1985; Graham, 2006; Koehler, 1988; Lemma, 1993; Tang, 2003). Yet researchers have noted that teaching practice can have positive and negative consequences on student teachers (e.g. Koehler, 1988; Korthagen, et al., 2006; Sabar, 2004). In addition, teaching practice experiences have been routinely criticized (Edmundson, 1990; Feiman-Nemser and Buchman, 1985; Tang, 2003; Tickle, 2000; Wilson, 2006).

Competence refers to appropriate prior knowledge, skills, attitudes, and abilities in a given context that adjust and develop with time and needs in order to effectively and efficiently accomplish a task. To be competent is not the awareness, the attainment, or even the knowledge of the various attributes within the document, although all of these play a part. To be competent is the just a position of this knowledge with the application of that knowledge in a teaching practice. In other words, a competent individual is one who effectively and efficiently accomplishes a task [instructs] in a given context using appropriate knowledge, skills, attitudes, and abilities. In other words, the more competencies that an instructor possesses, the higher the propensity that courses instructed by that instructor will result in positive outcomes for a greater number of students.

Teachers should use the competence as a tool for professional assessment and for rating themselves. There are five important competencies which are essentially required for an effective teacher viz., Subject matter knowledge, Communication skill, Instructional practice, Evaluation and Problem solving. (Shashi Shukla, 2009). Edmund Short (1985) attempted to clarify the confusion by presenting four different conceptions of competence. Firstly, competence is taken
as behaviour or performance, in doing of particular things independently with purpose or intent. Secondly, competence is taken as command of knowledge or skills, involving choosing and knowing why the choice is appropriate. Thirdly, competence can be seen as level of capability which has been found ‘insufficient’ through some judicious and public process, and this sufficiency indicator may fluctuate since it involves a value judgment. Fourthly, competence involves the quality of a person or state of being, including the characteristic behaviours like "performance, knowledge, skills, levels of sufficiency, and anything else that may seem relevant, such as intent, or motives, or attitudes, or particular qualities". According to Short (1985) the fourth definition implies that many theories about teacher competence can exist, all of which can be justified. In addition to qualitatively different conceptions of teaching, developmental and contextual variations also play a role in defining teacher competence. Thus, how teacher competence is defined depends on a number of things (Ashburn, 1987). The definition depends on the outcomes desired from teaching, which ranges from increased classroom average scores on standardized objectives, generally expressed in performance terms that delineate a variety of instructional skills and competence". Taylor, Middleton, and Napier (1990) have also advocated that the major thrust of teacher education programmes is to maximize the professional competence of teachers.

The importance of teachers’ competence is emphasized and named as “good practices”. The teacher competence varies in teaching arts and science subjects. The definition of competencies of science teachers and their taxonomy are very important in understanding the educational reforms in European context. The recent literature and many reforms in the field of science teacher education suggests that teacher preparation has a “threefold structure” with the anchoring pillars such as Subject Matter Knowledge (SMK), Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK). Science education programs should
pay more attention into the learning of science in social and technological context. The reform in the educational field has to pay a special attention on science teachers’ competencies (Adrienne Kozan Naumescu, 2008)

According to Illinois State Board of Education (ISBE) Illinois State Board of Professional Teaching Standards, “The competent teacher understands the central concepts, methods of inquiry, and structures of the discipline” in addition to an advanced level of knowledge in the content. Virgil E. Varvel Jr (2007) indicated the various competencies required for the teacher or instructor. According to him, the competent instructor

♦ should be qualified in the given field of study and demonstrates knowledge in the content area.
♦ undergoes continual professional development in teaching practice and lifelong learning.
♦ continually develops knowledge and skills in technology, including current and emergent technologies
♦ is able to judge the credibility, clarity, validity, reliability, accuracy, currency, and quality of course resources in the given topic of study
♦ creates and selects learning materials and experiences appropriate for the curriculum, the students, and principles of effective instruction.
♦ utilizes a variety of appropriate technologies (such as simulations, multimedia, etc.) designed to reach course objectives and to promote skills relevant to the field of study. There must be some sort of flexibility and variation in the instruction to best reach the most students in the given content.
♦ understands how a student's physical, social, emotional, ethical, and cognitive development influences learning. This knowledge is required in order to effectively monitor students and to address such issues when
planning instruction, selecting materials, and actively teaching/guiding students to knowledge acquisition.

♦ should map knowledge to be acquired using a concept map or other technique as appropriate and needed.

♦ the instructor should be able to demonstrate knowledge to students by mapping its interconnection with other knowledge. Such knowledge will also assist the instructor in answering student questions and in general decision making about course materials.

♦ be able to effectively educate and guide the students toward new cognitive structures and meaningful educational outcomes using proven techniques and personal skill.

♦ encourages metacognition within students and actively assists linking of new ideas and concepts to already existing ones. Thinking about knowledge and the structure of that knowledge within one's mental schema helps to reinforce it and properly organize it within one's knowledge base.

♦ elicits critical and active reflection from the learners about what they are learning and how it is applied in their own practice.

♦ guides students towards understanding and recognition of their own and others' inferences for validity, timeliness, reliability, and quality.

♦ demonstrates and expects higher-order critical thinking and problem solving. Such skills which have high value in work place are developed among the students when technology is used.

♦ encourages students to consider alternative explanations of their own experiences. Multiple viewpoints and multiple 'ways of knowing' are accepted in the formation of learning structures.

♦ uses innovative approaches to knowledge development in students since such innovations can lead to increased motivation among other things.
allows student criticism or questioning of instructor's views as appropriate and yet maintains a clear position of authority.

In fact teachers of science are required to possess the above mentioned competencies. Also it is imperative to ascertain the status of science education in India and other parts of globe. School science education in pre independent India as well as school education in India in general during 1900-1947 was not satisfactory on any criteria to meet the ambitions of the younger generations. Only after the independence the practice of science had come to acquire a nationalistic hue. The achievements of Raman, Saha, and Bose in the face of tremendous odds were regarded as points scored against the colonial rulers. School education and science education on the other hand, followed the model set up by the British. The idea that all children should have access to schooling was still in the future. Gandhi and Tagore proposed alternative models, but the mainstream did not adopt them. With Independence came a model of economic development that set great store by science and technology. Nehru’s dream was of a modern, prosperous India propelled by science and technology. Naturally, school science education received special attention in the brave new world of Nehru’s India, though not in a systematic fashion. Today India has 48.7 million people who have at least a graduate degree and about a fourth of these have a background of science education. Scientists were the pilots of this new India, and there was an understandable desire to produce more and better scientists. This perhaps explains the direction school science education took after Independence.

In India, science was not made a compulsory subject in schools until after independence, in spite of the fact that the Wood’s Education Despatch had recommended the introduction of science education in India as far back as 1854 (Nurullah and Naik, 1949). Following the recommendations of the Wood’s Despatch, the Universities of Calcutta, Bombay and Madras were established on
the lines of the London University. However, school education in general and science education in particular, languished during this period. Even after the British Crown took over the administration of India from the East India Company, there was not much improvement in the school education scenario. The first Indian Education Commission (Hunter Commission) in 1882 had also recommended the study of modern science in schools, in addition to westernization of the rest of the school curriculum. Since the beginning of the 20\textsuperscript{th} century, Indians began taking a keen interest in educational matters, partly due to dissatisfaction over Lord Curzon’s educational policy and partly due to the rise of national consciousness. The only noteworthy fact, as far as science education is concerned, is the establishment of ‘The Association for the Advancement of Scientific and Industrial Education of Indians’ at Calcutta in 1904. One of its objectives was to raise funds for sending deserving Indian students to Europe to peruse advanced studies in science.

Despite Curriculum reforms and inputs from decades of research in science education, science curricula in many parts of the world, especially in the non-western countries are still heavily influenced by the developments stemming from the thinking of the 1960’s, i.e., science education with a heavy thrust on producing scientists and technologists. Another cause for concern is the insularity of science teaching to the difference in the nuances of even major cultures of the world like Indian, Chinese and African (Holbrook, 2002). Apart from these generic problems, instruction in science in most Indian schools suffers from the following drawbacks as well (Vaidya, 1999):

- There exists a hiatus between planning and implementation of science education policy.
- Science teaching almost solely based on the prescribed text books.
Science teaching is still verbal in nature. There is very little practical work up to the eighth standard. In the higher classes laboratory work is recipe bound, defeating the very purpose for which it was introduced.

Science was made a compulsory subject for all children in India up to class X after Independence (Rajput, 2000). Everybody had the benefit of several commissions and committees on education since then. The report of the Secondary Education [Mudaliar Commission Report, (1952)] recommended the study of general science at the Junior Secondary stage, i.e., from standards 6 to 8. At the higher secondary stage, i.e., from standards 9 to 12, a diversified curriculum was to be followed. However, the commission recommended that a common, core group of subjects that includes science, be taught to all students irrespective of their diversified courses of study (Report of the Secondary Education, 1952).

The report of the Education Commission (1966) made detailed recommendations on the teaching of science in the first ten years of schooling. The following are some of the salient features of the recommendations of the Kothari Commission (Rajput, 2000):

- Science teaching at the primary stage should be related to the child’s environment.
- At the upper primary stage, the Commission recommended acquisition of knowledge and ability to think logically be the primary objective of teaching science.
- At the lower secondary stage, science was to be developed as a discipline of mind and knowledge.
- The Commission also recommended advanced level science courses in lower secondary school for talented students with necessary facilities of staff and laboratory.
As regards school science curriculum, the commission suggested that the curriculum in rural and urban schools be tailored to meet local needs. While school science should be linked to Agriculture in rural areas, technology and the impact of industrialization should be part of science curriculum in urban schools. However, the attainment level of rural and urban students should be the same. The Commission had also made recommendations on methods of teaching science (Kothari, 1966):

♦ An investigatory approach should be adopted in teaching science subjects.
♦ The connection between science, agriculture and industry has to be stressed.
♦ Science teaching should reflect the interests of the local community in order to make it realistic, interesting and useful.
♦ Teaching of science at the secondary stage can be built around home technology i.e., gadgets commonly used at home.

The 1986 National Policy on Education was subsequently revised in 1992. The salient points that relate to science education in this document are (NPE, 1992):

♦ Science will remain as a core subject in the first ten years of school education.
♦ The objectives to be fulfilled through science education have to be clearly articulated.
♦ The teaching/learning of science should be so designed as to cater to the individual requirements of the students and serve the basic right of every student to learn science.
♦ Science education has to reach the vast masses of people who have remained outside the pale of formal education. This is to be kept in mind while planning science education for the non-formal systems.
Science curriculum designed for the secondary level should keep in mind the future manpower requirements for economic growth as well as for ideal citizenship to live effectively in a science/technology-based society.

Integrated science has to be taught in schools up to class X.

The laws and principles of science which are operating in the environment should be used for creating desired teaching/learning situations. The performance of activities is to be given top priority in the teaching/learning of science.

As a follow up action to the 1992 National Education Policy the NCERT set up a committee on science education under the chairmanship of Prof. Yash Pal. The Yash Pal Committee made suggestions on the dimensions of scientific literacy to be covered by science education in the first ten years of school. UNESCO has mooted the goal of Scientific and Technological Literacy (STL) for all. Every citizen needs to be aware of trends in science, cope with technology in everyday life, and be able to take considered positions on science-related issues of social importance such as the height of a dam, the location of a nuclear power plant etc.

Lately, India’s science academies as well as policy-making bodies have been expressing great concern about school science education, and have launched several new schemes. We are simply not producing young scientists of sufficient quality in sufficient numbers. In other words, the school science that leaves the majority of students bored also fails in its primary aim of producing scientists.

NCERT, in its National Curriculum Framework document of 2005, addresses the issue afresh. The “product” obsession of school science is acknowledged. For the first time, HSTP and other similar efforts find place in a major policy document. Moving towards a curriculum that is less laden with facts, weakening disciplinary boundaries and linking school knowledge with outside knowledge are its avowed goals. While welcoming these efforts, it must be
realized that the prevalent model has failed, both from the wider perspective of education and its aims, and from the narrow one of producing scientists. It is imperative to move to a new model of school science education, in which science is not alien, but organically linked to children’s experiences. The processes of science have to be given due importance, and children have to be given opportunities to do things “hands-on.” Above all, science should emerge as something alive, fallible, and therefore exciting. Such a model will meet the wider aims of science education, and at the same time is more likely to encourage potential scientists who want to study science.

The NCERT in its National Curriculum Framework for School Education (NCERT, 2000), stipulating that the primary goal of school science education should be the promotion of scientific literacy, has incorporated these dimensions:

1. Understanding the nature of science.
2. Ability to use the process of science.
3. Ability to properly apply appropriate concepts of science.
4. Ability to understand values that underlie science.
5. Ability to understand and appreciate the joint enterprise of science, technology and society.
6. Ability to develop rich and more satisfied view of the universe and to continue science education throughout life.
7. Development of certain psychomotor (manipulative) skills, which are required in day–to-day life situations.

The Test of Basic Scientific literacy, covers the first, third and fifth of the above-mentioned dimensions as these are the ones that lend themselves to paper and pencil type of empirical measurements.
Thus there has been emerging in post-independent India a vision for quality science education in the nation. Despite this vision and the efforts taken by the NCERT, SCERT, The Department of Science and Technology of the Government of India, and a few non-Governmental agencies, schools remain out of tune with these developments. Keeping these factors in view, it is hoped that the UNESCO’s initiative *Project 2000+* which stresses on the active involvement of the teachers of science both in recognizing and initiating changes, would help alleviate some of the problems by overcoming the resistance for change as it is in contrast with the top-down approach of most of the earliest efforts at reforms.

For the education in schools, the Government of India established the National Council of Educational Research and Training (NCERT) in the early 1960s. It has been the key player in all aspects of science education in schools, including policy formulation and implementation, curriculum development, textbooks production and teachers’ training.

The Government of India is trying to encourage science education by dispensing scholarships to young science graduates through different schemes like ‘Catch Them Young’ mooted by CSIR as the nodal agency and ‘Kishore Vaigyanik Protsahan Yojana’ (KYPP) mooted by DST. The need for improvement of science education is a major national issue (National Commission of Excellence in Education, 1983). There is intense pressure for reform, and existing curricula and instruction have been declared largely inadequate (Hurd, 1986). The problem was recognized as especially severe in elementary education more than a decade ago (National Science Foundation, 1978). Stake and Easley (1978) concluded that few students were likely to experience even one year of substantial science instruction from Kindergarten through the sixth grade. Five years later Mechling and Oliver (1983) noted that most of the nation’s schools still lacked an adequate elementary science programme. Many elementary teachers feel
unqualified to teach science and devote little or no time to it (National Science Teachers Association, 1983). Without substantial reforms most of the nation’s youth will be deprived of systematic science instruction during the formative elementary years when they may benefit most from the learning processes and thinking skills promoted by science study.

A real need and significant need is arising for researchers to examine models of professional development which will impact on the way in which teachers think about and reflect on science in the modern world (Grey & Bryce, 2006). Pedagogy that is relevant for teachers to understand and be able to teach particular science concepts and/or employ strategies. Hence Instructional Design is an instrumental for understanding the pedagogy of the science content in particular which in turn helps a science teacher employ appropriate strategies.

**Fig. 1.F.1 Instructional Design**

Research has shown that particular ways of delivering instructions are more effective than others. Different kinds of learning goals require different approaches to instruction. The instructional designer can determine the best
instructional conditions or methods to deliver learning outcomes. The Instructional designer develops instructional strategies that are tailored to the learning objectives and the needs of the learners.

The aim of instructional design is to make the instruction effective, efficient, appealing and cost-effective. The instructional designer uses a variety of interactive media to improve learning and address learning objectives. Traditional face-to-face teaching methods can be enhanced by, or even replaced by innovative e-learning methods. The instructional designer is the expert in finding the "right" technology to support "good" pedagogy.

The Information Age is making new demands on us all. Education must find ways to face these new challenges. A teacher can no longer see learners as empty vessels that can be filled with information. The information now resides out there, distributed across a vast network and shared between all people. The challenge now is to help people use this information safely, wisely and productively as they adapt to a rapidly changing world. A teacher needs to prepare "students to learn, work and live successfully in a knowledge-based, global society" (Newhouse, 2002). The Instructional Designer is there to facilitate learning in this new epoch, the Knowledge Age.

In deed Instructional Design is the systematic process of translating general principles of learning and instruction into plans for instructional materials and learning. Instructional Design is the creation of detail specifications of an instructional system which involves development, implementation, evaluation and maintenance. In other words, instructional design is a process as well as a discipline. Instructional Design is the art and science of creating an instructional environment and materials that will bring the learner from the state of not being able to accomplish certain tasks to the state of being able to accomplish those tasks. Instructional design is based on theoretical and practical research in the
areas of cognition, educational psychology, and problem solving. Basically, one can think about it as the creation of materials that will bring about a change in abilities in the student and bridge the gap from what the student can't do to what you would like them to be able to do (Curtis L. Broderick, 2001).

The origin of instructional design procedures have been traced to World War II (Dick, 1987). During the war, a large number of psychologists and educators who had training and experience in conducting experimental research were called on to conduct research and develop training materials for the military services. These individuals, including Robert Gagne, Leslie Briggs, John Flanagan, and many others, exerted considerable influence on the characteristics of the training materials that were developed, basing much of their work on instructional principles derived from research and theory on instruction, learning, and human behaviour (Baker, 1973; Dick, 1987; Saettler, 1990). Moreover, psychologists used their knowledge of evaluation and testing to help assess the skills of trainees and select the individuals who were most likely to benefit from particular training programs. For example, at one point in the war, the failure rate in a particular flight training program was unacceptably high. In order to overcome this problem, psychologists examined the general intellectual, psychomotor and perceptual skills of individuals who were able to successfully perform the skills taught in the program, and then developed tests that measured those traits. These tests were used to screen candidates for the program, with those individuals who scored poorly being directed into other programs. As a result of using this examination of entry skills as a screening device, the military was able to significantly increase the percentage of personnel who successfully completed the program (Gagne, personal communication, 1985). Immediately after World War II, many of the psychologists responsible for the success of the military training programs continued to work on solving instructional problems. Organizations such as the American Institutes for Research were established for
this purpose. During the late 1940s and throughout the 1950s, psychologists working for such organizations started viewing training as a system, and developed a number of innovative analysis, design, and evaluation procedures (Dick, 1987). For example, during this period, a detailed task analysis methodology was developed by Robert B. Miller while he worked on projects for the military (Miller, 1953, 1962).


Stage 1: Define instructional goals.

A goal may be defined as a general statement of desired accomplishment. It does not specify exactly all of the components or steps or how each step will be achieved on the road to accomplishing the goal. Example Goals: (1) Students will master the procedure of a generic history and physical. (2) Students will understand the biochemistry of diabetes.

Stage 2: Conduct an instructional analysis

Identify what learning steps will be involved in reaching the goal. This is done through a task analysis, which identifies each step and the skills needed in order to complete that step, and an information processing analysis, which identifies the mental operations the learner needs to employ in performing that skill. The task analysis is performed by asking "What are all of the things the student must know and/or be able to do to achieve the goal?"

Stage 3: Identify entry behaviors/learner characteristics

Having determined via the instructional analysis which steps and skills the learner must accomplish, it is now necessary to identify the knowledge and skill level that the learner possesses at the outset. Although there may be pronounced differences from learner to learner in their knowledge and skill levels, the instruction must be targeted as much as possible to the level of the learners' needs.
Stage 4: Develop performance objectives.
At this stage, it is necessary to translate the needs and goals into objectives that are sufficiently specific to guide the instructor in teaching and the learner in studying. In addition, these objectives form the blueprint for testing as a means of evaluating both the instruction and the learning that has occurred. Example: The student will be able to explain the role of the Krebs cycle to thermogenesis.

Stage 5: Select an instructional method.
The purpose of selecting an instructional method is to identify and employ teaching strategies and techniques that most effectively achieve the performance objectives. Current educational theory and research support the use of instructional methods that make students active learners (e.g., lecture, lab, small group discussion, case-based study, simulations, independent study, etc.).

Stage 6: Assemble instructional material.
Once the instructional methodologies have been identified for each objective or unit of content, it is important to assemble the necessary instructional materials. The materials may be in various forms: print, computer, audio, audio-video, etc. Although the necessary instructional materials may already exist, they may need improvement or revision. For example, slides that have been used in the past but that have been problematic, need to be modified. The danger of settling on preexisting instructional materials is that some instructors may allow the materials to determine the direction of the instruction rather than vice versa. Currently, more instructors are using the Web as a way of making didactic information available to students, rather than using lectures or transcripts.

Stage 7: Plan and conduct formative evaluation.
Formative evaluation, evaluation that occurs from feedback while the instruction is in progress, provides data for revising and improving the instructional materials that were used and those that are yet to be used. It is important to remember that sometimes the plans that look so good on paper actually fail in practice. When
possible, test instructional materials with one or a small group of students to
determine how students use the materials, how much assistance they need, etc.
Considering the teaching methods implemented and the course materials provided
are students learning what they should be?

Stage 8: Plan and conduct summative evaluation.

Summative evaluation, evaluation that occurs at the end of the instructional effort
(unit, course, etc.), provides data on the effectiveness of the instructional effort as
a whole. This is the evaluation that provides information on how the whole
instructional unit enabled the learner to achieve the objectives that were
established at the outset.

The present study takes cognizance of the different stages of instructional
design in its development of instructional design. Moreover, comprehension of
complex science topics occurs from the creation of new understanding of the
information by the teacher. However, teachers are not very successful generating
their own meaning, especially in computer based learning environments in which
teachers are required to make decisions about their teaching-learning process,
since they rarely help students regulate their own learning process cognitively or
metacognitively.

Metacognition is an awareness of the content of one’s own thinking and
conceptions (Hennessey 1999). Engaging metacognition can help strengthen
scientific understanding because it helps build connections between science
experiences and ideas (Blank 2000). Constructivism, which maintains that new
knowledge is built upon a learner’s prior understanding, including beliefs and
knowledge about science (Coburn 2000), underscores the need for reflection on
what is being learned. By providing opportunities to reflect on what a learner
comprehends at a point in time, through written and verbal means, a learner can
become aware of their prior conceptions. This awareness is a first step to help
better understand more accurate or new concepts, and even learn how to monitor their own learning process. Metacognitive research has shown that metacognition is an important predictor of academic performance; students are able to effectively distinguish information they know and do not know are more likely to review and retain new information (Dunning, Johnson, Ehrlinger, & Kruger, 2003; Dunslosky & Thiede, 1998; Kruger & Dunning, 1999). Gunstone (1994) stresses that all learners are metacognitive and that the associated pedagogical goal should be to enhance metacognition. He suggests that enhanced metacognition is a learning outcome in itself, as well as a having a critical impact on the achievement of content-based learning outcomes. He argues that enhanced and appropriate metacognitive abilities will only be achieved by means of an integrative perspective on metacognition, in which metacognitive training is recognized to be intimately bound up in issues of content and context. Self-regulated learning, or self-regulation, on the other hand, is “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (Pintrich, 2000b).

Brown (1980) helped to differentiate between cognitive and metacognitive processes. He suggested that the main function of cognition is to resolve problems and to bring cognitive enterprises to a good end. The primary purpose of metacognition is to regulate a person's cognitive processes in solving a problem or executing a task. Metacognition involves executive insight such as recognizing what is not understood, consciously increasing concentration to block distractions and deliberately using prior experience to increase retention and understanding, among other things (Brown, 1987).

In essence, metacognition is a reflection and evaluation of the thinking process and not simply providing declarative knowledge production as evidence of
learning. Metacognition clearly involves more executive components such as setting goals, selecting strategies and monitoring their effectiveness in the accomplishment of learning tasks. By definition metacognitive strategies surround the learning activity and are often triggered by the success or the failure of a learner's selected or habitual strategies (Roberts & Erdos, 1993). One of the key challenges with metacognitive strategies is that they are often used sporadically. Sometimes these strategies are initiated at the start of a given learning task but sometimes they are initiated only when established or habitual cognitive strategies fail (Roberts & Erdos, 1993). The unsystematic use of metacognitive strategies can also be a determining factor as there appears to be an important difference between the knowledge of metacognitive strategies and their systematic application.

Several science educators embraced the concept of metacognition. Prominent among them were the antipodean trio of John Baird, Dick White and Dick Gunstone who contributed substantially in moving metacognition into mainstream science education research and who sought to engage science teachers and their graduate students, many of whom were practicing science teachers, in considering how they might develop students’ metacognition.

Blank (2000) recommends a metacognitive learning cycle that includes explicit conceptual status checks to accompany each learning cycle phase. Schraw and his colleagues (2006), describe a set of instructional strategies to improve self-regulation in the science classroom, including inquiry, collaboration, and mental models. Within these strategies, teachers can promote metacognition by helping students plan and monitor investigations, evaluate explanations and models, and self-reflect on their learning. By using metacognitive teaching strategies, science teachers can help students regulate their learning, thereby achieving deeper and more durable scientific understanding.
The National Research Council (Duschl, Schweingruber, and Shouse 2007) recommends that teachers of science use metacognitively guided learning in their science teaching. They suggest that teachers help students become aware of their initial science ideas, make predictions and provide reasons for their predictions, and discuss and compare their ideas with others.

"Metacognition" is one of the latest buzz words in educational psychology. Metacognition enables us to be successful learners, and has been associated with intelligence (e.g., Borkowski, Carr, & Pressley, 1987; Sternberg, 1984, 1986a, 1986b). Metacognition is an individual’s knowledge of their own cognitive processes and their ability to control these processes by organizing, monitoring and modifying them as a function of learning. It refers to the ability to reflect upon the task demand and independently select and employ the appropriate reading, writing, math or learning strategy.

Metacognition is a higher order thinking that involves active control over the thinking processes involved 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 for both students and teachers. Metacognition has been linked with intelligence and it has been shown that those with greater metacognitive abilities tend to be more successful thinkers. Metacognition also refers to learners' automatic awareness of their own knowledge and their ability to understand, control, and manipulate their own cognitive processes.

Metacognition consists of three basic elements:

- Developing a plan of action
- Maintaining/monitoring the plan
- Evaluating the plan
Before - When you are developing the plan of action, ask yourself:
What in my prior knowledge will help me with this particular task?
In what direction do I want my thinking to take me?
What should I do first?
Why am I reading this selection?
How much time do I have to complete the task?

During - When you are maintaining/monitoring the plan of action, ask yourself:
How am I doing?
Am I on the right track?
How should I proceed?
What information is important to remember?
Should I move in a different direction?
Should I adjust the pace depending on the difficulty?
What do I need to do if I do not understand?

After - When you are evaluating the plan of action ask yourself:
How well did I do?
Did my particular course of thinking produce more or less than I had expected?
What could I have done differently?
How might I apply this line of thinking to other problems?
Do I need to go back through the task to fill in any "blanks" in my understanding?

Metacognitive thought is an essential skill for learning. It ensures that the learner will be able to construct meaning from information. To accomplish this, the learner must be able to think about their own thought process, identify the learning strategies that work best for them and consciously manage how they learn. Metacognition is a double-checking process. It is a routine process that can be activated in almost any situation. Since checking is a mental operation, the instruction to check twice is an example of thinking about a mental operation, so it is metacognition. Double-checking saves time and prevents wasted resources.
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. An example is knowing the formula for calculating momentum in a physics class (momentum = mass times velocity). Procedural knowledge is knowledge of how to do something, of how to perform the steps in a process; for example, knowing the mass of an object and its rate of speed and how to do the calculation. 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. For example, students need to recognize that an exam word problem requires the calculation of momentum as part of its solution. Thus, it is a pioneer effort of the present study to have attempted to integrate the ideas of metacognition into the development of instructional design.

In recent years, with the rapid development of emerging technologies, the integration of Information and Communication Technology (ICT) has increasingly attracted the attention of teachers. A simple combination of hardware and software will not make integration naturally follow (Earle, 2002). Teachers need to plan thoughtfully before they start ICT integration into a curriculum. For instance, they have to choose the correct ICT tools for particular learning objectives or contexts, modify existing resources or develop new learning environments to engage specific groups of learners, or decide scaffolding strategies for student-centered learning.

The incorporation of technology into teaching and research is one of the most important challenges for education today. It is time to move beyond the walls of our classrooms to join forces with other institutions and societies to revitalize education. The use of technology in teaching learning process that will greatly
contribute to meet student needs for learning anywhere, anytime. Information and Communication Technology, a broad subject concerned with technology and other aspects of managing and processing information. As more and more emphasis is laid on the use of Innovation and Information and Communication Technology as a powerful medium towards improvements in the field of education, Technology has become a huge enabler, for the complete teaching-learning process. Using technology to enhance the quality of teaching and learning has always been one of the goals of present education. Today’s computer-based technologies offer powerful new ways to provide students with direct experience in the classroom curriculum. And, through using teaching and learning resources that can be manipulated electronically, technology can extend the experience of students far beyond the time and space limitations of conventional materials.

Technology can be used for individualized instruction in order to bridge the gaps between the teaching styles and the learning styles. The use of technology can be made to address the visual learners, auditory learners and kinesthetic learners. In an ordinary classroom with one teacher, it is difficult for the teacher to respond and provide feedback to each student. The programmed instruction models as suggested by Skinner can be used to provide learners learn at their own pace and give immediate feedback. Multimedia tools provide a wide range of sensory stimuli. It is said ‘I hear and I forget, I see and I remember, I do and I understand.’ The animations, simulations, software packages to teach various subjects, speech, music, multimedia networks, image enhancements, etc. create virtual realities and experience for the learners, which in turn, help in making learning a more direct, useful, and joyful experience and retain knowledge for a longer time (Shamsha Emanuel, 2010).

The starting point of a digital classroom is a teacher. Teachers must be trained to effectively use the technology for planning and student instruction. The
role of the teacher has subtly shifted from being the sole 'provider' of knowledge to being a facilitator as the student explores for himself, the expansive world of knowledge. From being a 'Sage on the Stage', to being a 'Guide by the Side'. In today's world, lifelong learning has become a critical determinant of success. And hence, more than mastering various competencies, the key skill required is learning how to learn. The Learning Management System (LMS) harnesses the potential of technology to improve learning outcomes and to prepare students for the accelerated changes in the world in which they live. According to the UNDP statistics in the year 2001, almost 80% of the teachers in developing countries feel that they are not prepared to use the technology. However, efforts are been made to make the teachers aware of the use of technology through pre-service and in-service courses. In addition, Edu. Tech. programs also aim towards making the teacher's techno savvy and teach using the computers. Hence, the use of Information Technology in teaching requires competencies on the part of the teacher and has indeed made the profession more challenging. It is rightly said, 'an able teacher need to find ways and means to improve their teaching techniques – using IT is one of them.' Educational Innovations certainly do not come about automatically. They have to be invented, planned, initiated and implemented in a way that will make educational practices more adequately geared to the changing objectives of instruction and make them more consistent with changing standards of instruction. (Shamsha Emanuel , 2010) e-Learning provides a way for teachers to gain new knowledge and skills. ICT also facilitate the new paradigm in teacher training that is emerging. Teacher training now involves a continuum of learning, from pre-service training, to in-service workshops and short courses; and to ongoing lifelong professional development.

In "Teacher Professional Development in the Use of Technology", Sam Carlson and Cheick T Gadio (2004) list the following as being fundamental components in any professional development for technology programme:
Direct connection to student learning. The goal of teacher professional development is improved student achievement. The ICT that is used in the classroom should be relevant to student needs.

Hands-on technology use. This requires development of core technology competencies and skills and actual application of skills in the classroom.

Curriculum-specific applications. To the fullest extent possible, teachers need to see a direct link between technology and the curriculum for which they are responsible.

New roles for teachers, as facilitators and guides, not simply as lecturers or instructors.

Active participation of teachers and collegial learning.

Professional development as an ongoing process.

A national vision is required for attracting and retaining teachers, strengthening teacher education and providing adequate professional learning. Improvements in teacher education and conditions in the teaching profession will flow to improvements in science teacher education and the quality of science teaching. Although considerable criticism is found in the literature about the nature of the science curriculum and the need for change, it is its implementation which is the crucial element in students’ learning. The teacher is the critical factor in student learning, interest and motivation to learn (Wiliam, 2006). The groundwork for effective teaching occurs during initial teacher education. Consequently, programmes, and the teacher educators who present them, must offer contemporary science education that provides adequate training in both content and pedagogy. Once they enter their own classrooms, teachers must keep abreast of changes in educational contexts and science and technological developments that affect the currency of the science curriculum. Better programmes are required for providing accurate information regarding science careers for students, career advisors, and parents, and for more informed access to
those resources that already exist. In addition, a national effort is required to encourage young people to consider taking up those careers and continue their participation in science (Denis Goodrum Leonie J. Rennie 2007).

Numerous instructional design models are currently available to help teachers integrate ICT into a curriculum. Examples of these include: the ASSURE model (Analyse learners; State objectives; Select media and materials; Utilize media and materials; Require learner participation; Evaluate and revise) described by Heinich, Molenda, Russell, & Smaldino (2001), the ICARE (Introduce; Connect; Apply; Reflect; Extend) model (Hoffman & Ritchie, 1998) and the systematic planning model (Wang & Woo, 2007a). These models provide useful guidelines for incorporating ICT into teaching and learning from different perspectives. However, studies have shown that teachers who are trained in using linear instructional design models are often reluctant to apply them in real instructional planning processes due to the impracticality of the models in a complex school environment (Mishra & Koehler, 2006; Neiss, 2005). In the present study, a Metacognitive Instructional design an innovative design of its first kind is attempted for the development of e-content for student-teachers of science at secondary level.

1.2 Cognitive perspectives on Science Education

Complex science topics deal with complex systems that have multiple interconnected components, and whose behavior is not explained exclusively by examining the isolated components, since the phenomena result from the multiple interactions of the components (Sabelli, 2006). The process of pollination in plants is a good example of a complex science topic. The pollination in plants has multiple components such as anthers, stigma, pollen tube, pollengrains and ovary connected with other systems. Those components function simultaneously by interacting with each other. There are some underlying principles explaining the
process of pollination by the anemophily, entomophily, hydrophily and Ornithophily. So, to understand the principles of how pollination as a process works, learners need to integrate all properties and functions of each individual component. Mere memorization of the components of the system leads to little understanding of how the system works (Hmelo-Silver & Azevedo, 2006). This cognitive integration process can occur when learners use cognitive and metacognitive strategies, and when they are motivated and responsible for their own learning. This concept is in line with the knowledge generation process of Wittrock's generative learning theory (Wittrock, 1974, 1990, 1991, 1992).

According to the generative learning model, to comprehend a complex topic, learners need to ...selectively attend to events and generate meaning for events by constructing relations between new or incoming information and previously acquired information, conceptions, and background knowledge" (Wittrock, 1992, p. 532). In this model, comprehension and understanding result from the generation of relations both among concepts and between experience or prior learning and information. That is, comprehension occurs from the creation of new understandings of the information by the learner, rather than transferring the presented information (Grabowski, 2004).

Only those activities that involve the actual creation of relationships and meaning would be classified as examples of generative learning strategies. Restructuring of environmental information by definition requires the learner to generate either organizational or integrated relationships and construct personal meaning, thereby qualifying as being generative. One very basic assumption of this model is that learners are not passively receiving learning, but they are actively engaged in the construction of meaning as it relates to their preconceptions, abstract knowledge, everyday experience, and the context in which learning is occurring (Wittrock, 1974).
The most frequently used learning strategies employed in the name of generative learning are underlining and note-taking. Learners meaningfully relate what they read to information they already know (Rickards, 1979). Similarly, a learner naturally engages in generative activity through paraphrasing sentences to combine ideas from the passage, or to relate them to prior knowledge. Hence one can be old enough to understand the relationship between cognition and science concepts.

1.3 Rationale of the study

The Kothari commission report (1960) states, “If science is poorly taught and badly learnt, it is little more than burdening the mind with dead information and it could degenerate even into new superstitions”. Revised National Policy on Education (1996) envisaged launching of national mission for achieving universalisation of education and quality of education. It also emphasized the need for change in the teachers’ outlook of teaching and dissemination of instruction. The advancement of science has to be effectively conveyed to the students without much time gap. Therefore Science Teaching Competence becomes a crucial factor for the fast development of science and for the induction of interest among students to learn the basic and the latest advancement in science. The recent advancement in teaching and learning principles have to be adopted by the science teachers in order to bring out better results of teaching and learning. Metacognition, awareness of one’s own learning and taking active control of their learning strategies thereafter and e-content are the two important innovative educational technologies that have been focused in the present study along with a suitable instructional design. The present investigation focuses on the role of e-content approach in the teaching competence of the student-teachers of Science in the rural areas. The concept of Metacognition is used in the Instructional Design (ID) of the e-content as it will ensure the quality perspectives of e-content. For the
instructional designer the issue is not leaving the learner adrift in a sea of content without the tools to be successful but practical ways to maximize metacognitive strategy transfer and thus equip learners with the appropriate navigational tools to reach shore. The primary objective of metacognitive skills to instructional designers is to provide them with a bundle of strategies that will make them more active information processors, students who monitor and control their learning activities, making local adaptations as required to ensure attaining key learning objectives. The special aim of applying e-learning materials to science is to enable student-teachers to make their thinking visible, to state arguments for difficult concepts in science. This process is seen significant for learning metacognitive skills and it is supported with e-learning environment. The e-content technology and Metacognition not only enable the student-teachers to review their thought processes but also to get them exposed of modern techniques and hence student-teachers may be helped regulate their thinking processes and enhance their Science Teaching Competence. The research of Metacognition in science has given light on individual student-teacher’s performance in Science Teaching Competence and his or her metacognitive beliefs. (Brown, 1987; Schoenfeld, 1987). As most of the innovations in the educational practices are not exposed to the rural population, this study attempts to empower the Science Teaching Competence of student-teachers in the rural areas through an innovative technique, e-content with a Metacognitive Instructional design by the principle of “Reaching the Unreached”.

1.4 Scope of the study

The present study believes that Metacognitive orientation helps student-teachers exhibit cognitive processes, to analyze, and manage their own thinking in pursuit of knowledge acquisition in order to gain insight and creativity to become critical thinkers. If student-teachers, the future teachers are trained with innovative approaches, then a number of school going children will be benefited in future.
Therefore this study aims to develop and design an innovative strategy for enhancing the teaching competence of student-teachers.

One principle which suggested itself from the outset is that effective teachers tend to see ICT resources and tools as much more than an extension of “traditional” print resources, existing classroom practices, and “curriculum-as-content” transmission. The integration of ICTs in teaching and learning is more likely, if the tools and resources of the Internet, multimedia, and related technologies are seen as being integrally connected with literacy learning in the wider sense of learning as a matter of accessing information, communicating, and applying knowledge.

A study conducted on biology teachers showed that teachers found themselves incompetent in using teaching technologies (Koseoglu & Soran, 2004). It shows that, as technology continuously develops and changes, teachers did not deem themselves competent by only depending on the pre-service education they received and they were in need of more trainings. A study conducted on biology teachers about teachers’ expectations put forward that most of the teachers needed in-service training on innovations about both instruments and the content (Altunoglu & Atav, 2005).

e-Learning modules in pollination, osmosis and cell division pave the way for the student-teachers of science to interact with the components such as objectives, assessment, references, module, pros and cons, model on Science Teaching Competence, guidelines on e-content development, glossary, story board, evaluation, metacognitive instructional design and script writing, and facilitating the learning of these components at their own pace. The above mentioned topics in science deal with microscopic elements, the e-content are developed with the integration of multimedia components such as text, audio, video, animation and image which will ensure simulation for the student-teachers of science. e-Learning
modules facilitate the student-teachers or teachers of science on how to write a script and story board for the development of e-content of their own. Indeed the modules help them learn what, why and how of e-content.

Besides the above mentioned advantages the student-teachers or teachers of science will be exposed to an innovative teaching model on Science Teaching Competence using a Metacognitive Instructional design along with pros and cons of the topics discussed. e-Learning modules are prepared in such a way that they will provide multi-sensory experience to the learners. Also the learners will be able to visualize the entire content and attain mastery over the topics. It is understood that the development of e-learning modules are of their first kind prepared for student-teachers of science which explained how to teach the concepts in science.

1.5 Statement of the problem

Though the importance of science is realized, the method of teaching of science is rather crude in most of the schools in India. The student-teachers in generally do not get an opportunity to think independently and conceptualize the spirit of the subject while practice their teaching due to the lack of innovative methods in the classes. In fact the present state of teaching science in the majority of educational institutions at all levels needs a lot of overhauling. Hence, paramount importance must be given to the fact that the teachers of science should be trained and oriented with constructivist learning environment which consists of problem description and their multi-modal representation as the focus of learning, and the following interdependent components which assist student-teachers to understand and manipulate the difficult concepts in science: a collection of authentic information resources, related cases, cognitive tools to support knowledge construction and technology. e-Content learning encourages open-minded, reflective, critical and active learning. With e-content materials, the
student-teacher, the future teacher will understand that he or she is changing from a provider of facts to the one that facilitates a learning environment. It is in this assumption that the present study aims to find out the effectiveness of an innovative strategy with modern technological tools known as e-content with a Metacognitive Instructional design on Science Teaching Competence of student-teachers doing their B.Ed. degree in the teacher education institutions located in the rural areas. Science is a process as well as the product of that process. In its process form it suggests the ways and means of exploring the truth and in its product form it presents a systematic and organized body of useful knowledge. The form of science so emerged is the product of all facts connected with information, concepts, generalizations, laws and theories framed on the basis of vast and limitless fund of accumulated knowledge. The method or process adopted by science in the explanation of truth is quite unique and distinct from the methods adopted in such study by other subjects. It is known as scientific method and is characterized by the qualities like logically sound, highly valid as well as sufficiently reliable, impartial and objective in its procedure and approach. Hence the research problem has been selected and stated as “Empowerment of Science Teaching Competence of B.Ed. trainees through e-content with a Metacognitive Instructional design”

1.6 An overview of the study

Backdrop of the study, Cognitive perspectives of science education, Rationale of the study, Scope of the study and Statement of the problem are dealt in the conceptual Frame work. Second chapter deals with the development of a model on Science Teaching Competence and e-content. Studies pertaining to the present problem of research for the development of the model and the research design are reviewed in the third chapter. Fourth chapter deals with the design of the study which involves objectives, hypothesis, research design, construction and validation of the research tools. Analysis and interpretations drawn from the data
are provided in the fifth chapter. The final chapter gives summary of the major findings, Recommendations, Suggestions and conclusions. Bibliography is adhered to APA (American Psychological Association) format style. Annexure provides Science Teaching Competence Scale (STCS), Metacognitive Awareness Inventory for Science Student-teachers (MAISST), Metacognitive Instructional design Questionnaire for Student-teachers (MIDQST), Checklist on student-teachers’ knowledge towards ICT and Multimedia components (CLKICTMC), Interview Questionnaire on e-content for experts in Educational Technology and Interview Questionnaire on e-content for experts in Botany and Publications.