REVIEW OF RELATED LITERATURE
## CHAPTER II

REVIEW OF RELATED LITERATURE

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CHAPTER II

REVIEW OF RELATED LITERATURE

2.0 Introduction

This chapter deals with the review of the research done on constructivism. The studies reviewed were compiled under these four sections viz.,

2.1 The historical development of constructivism.

2.2 Studies related to the characteristics of constructivist teaching and learning.

2.3 Studies related to the effectiveness of constructivist approach in teacher education and other subject areas.

2.4 Studies related to the effectiveness of constructivist approach in science education.

2.1 The historical development of constructivism

The learning of science by children and older students, no less than scientific research itself, is in its own way an investigative, constructive process. The general philosophy that supports this view has come to be called constructivism. It may tend to be taken up as practice and theory still under development.

As theory, constructivism has had two major historical sources. One source is philosophical, a general theory of knowledge that can provide background and
support for more specific educational theory and practice. The other source is the experiences of reflective practitioners, teachers and those who seek to help and learn from them. A third source, growing in recent times is a professional research community, seeking to bring theory and practice more coherently together.

Constructivism is not a new concept. It has its roots in philosophy and has been applied to sociology and anthropology as well as cognitive psychology and education.

Recent trends in science teaching have seen phrases such as "students construct their own knowledge" or "students construct their own knowledge based on the existing schemata and beliefs." Yet these phrases grew out of an epistemology that has been around a long time. Aspects of constructivist theory can be found among the works of Socrates, Plato, and Aristotle (ranging from 470 to 320 BC.) all of which speak of the formation of knowledge. However, the main philosophy of constructivism is generally credited to Jean Piaget.

According to Fosnot (1993), Constructivism is derived from the field of cognitive psychology. The constructivist paradigm is based on the work of Piaget, Vygotsky and Bruner. However, it was Piaget who attempted to answer epistemological questions by scientific means. He believed that knowledge acquisition could be explained just as an evolutionary acquisition. The process of equilibration as described by Piaget implied that knowledge acquisition is a process in which the learner actively constructs his or her knowledge, which is known as Constructivism. Bruner (1966) along with Ausubel (1968) and Piaget (1972) stated that learning is
an active process and students construct new ideas or concepts based on the current knowledge. Pestalozzi came to many similar conclusions more than a century earlier. His basic pedagogical innovation was his insistence that children learn through the senses rather than words. However, Piaget became regarded as the father of constructivism and provided the foundation for modern day constructivism.

Kant (1983), the first major precursor said that scientific knowledge is actively constructed from our observational experience. For Kant, the metaphor of construction is pointedly appropriate. Kantian delineation of the investigative art is found in the writings of three American philosophers namely Pierce (1839 - 1914), who developed the theory of abduction the art of moving from novel phenomenon to hypothesis that would if confirmed, explain the phenomenon.

A second psychologist and philosopher was Dewey (1933) known in educational circles mainly for his association with progressive education movements. Kuhn (1970) analysed historical shifts from the presuppositions of scientific investigation and thought.

Perhaps the first constructivist philosopher, Giambatista Vico commented in a treatise in 1970 that "one only knows something if one can explain it". Basically defined, constructivism simply means that as we experience something new, we internalize it through our past experiences or knowledge that we have previously constructed.

For constructivists, learning is not knowledge written on or transplanted into a person's mind as if the mind were a blank slate waiting to be written on or an empty
gallery waiting to be filled (Locke, 1969). Constructivists use the metaphor of construction because it aptly summarizes the epistemological view that knowledge is built by individuals. Vygotsky (1978) recommended social interaction as a fundamental aspect of the development of cognition. He believed that everything is learned on two levels. First, through interaction with others and then integrated into the individual's mental structure.

Since Ausubel et al. (1978), theorists have argued that the construction of new knowledge in science is strongly influenced by prior knowledge, that is, conceptions gained prior to the point of new learning. Learning by construction thus implies a change in prior knowledge, where change can mean replacement, addition, or modification of extant knowledge. Learning, by construction, involving change is the basis of the Posner et al. (1982) conceptual change model.

According to Papert (1991), students should give themselves time to complete a task thoroughly giving their minds a chance to absorb new knowledge and allow true learning to take place. The second and third principles of learning are discussion and connections, i.e connecting new data with an already established schema to invest self-gained knowledge Piaget, (1980). The constructivist approach to learning is constructing a new knowledge each time. In the constructivist approach, the student creates his own knowledge. Through trial and error, peer cooperation, and hands on activities, students are able to envision and discover new possibilities of and within themselves.

Lerman (1989), following Kilpatrick(1987) suggested that the core epistemological theses of constructivism are as follows: i) knowledge is actively
constructed by the cognizing subject not passively received from the environment. 

; ii) coming to know is an adaptive process that organizes one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower.

Later Resnick (1983) summarized constructivism in three statements:

i) Learners construct understanding. ii) They do not simply mirror what they are told or what they read.. to understand something is to know relationships. iii) Bits of isolated information are forgotten or become inaccessible to memory. All learning depends on prior knowledge.

Besides this, Glaserfeld (1984), a radical constructivist said that the realist believes his constructs to be replica or reflection of independently existing structures, while the constructivist remains aware of the experiencer's role as originator of all structures... for the constructivist there are no structures other than those which the knower constitutes by his very own activity of coordination of experiential particles.

A study conducted by Watts and Bentley (1991), made a clear distinction between 'strong' and 'weak' constructivism. They also expressed that strong constructivism centres upon cognitive construction, constructive processes, oppositional critical realism, self-determination and collegiality.

In 1991, Wheatley proposed a model of constructivist teaching using the problem centred learning approach. He stated that each student must be encouraged to build his or her own conceptual constructs that will permit the ordering
of knowledge into useful problem solving schema. He even projected that the
teacher's role is to provide stimulating and motivational experiences through
negotiation and act as a guide in the building of personalized schema.

Saunders (1992) explained that constructivism could be defined as that
philosophical position, which holds that any reality is in the most immediate, and
concrete sense; the mental construction of those who believe they have discovered
and investigated it.

Brooks and Brooks (1993) explained that the constructivist vista is far more
panoramic and therefore elusive. Deep understanding not imitative behavior is the
goal. They claimed that teachers should not look for what students can repeat but
for what they can generate, demonstrate and exhibit. They have five guiding
principles of constructivism: (i) using the problems of relevance to the students in
instruction; (ii) learning is structured around primary concepts; (iii) valuing students'
point of view; (iv) adapting curriculum to address students suppositions and (v)
assessing students learning in the context of teaching.

Lynn Renz, B. (1996) carried out a study to examine how constructivist principles
relate to school assessment. Eleven principles for the development of a school
accreditation model from a constructivist perspective were presented.

In other words, as explained by Crowther (1997) what is supposedly found is
an invention whose inventor is unaware of his or her act of invention and who
considers it as something that exists independently of him; the invention then
becomes the basis of his or her world view and actions.
Cobb (1999) explained that constructivist learning theory predicts that knowledge encoded from data by learners themselves will be more flexible, transferable and useful than knowledge encoded for them by experts and transmitted to them by an instructor or other delivery agent. Baylor, Samsonov and Smith (1996) in their book have emphasised on constructivist approach of learning. In the fourth chapter "A collaborative class investigation into telecommunication in education", they quoted the words of Fosnot (1996) who referred constructivism as "a theory about knowledge and learning." According to constructivist theory, knowledge is "temporary, developmental, nonobjective, internally constructed, socially and culturally mediated," Fosnot presented learning as "a self regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights". Learners construct new models which are refined through "cooperative social activity, discourse and debate". It changes the dynamics of the traditional classroom by empowering the learner as the focus and architect of the learning process while redefining the role of the instructor is to be a guide and helper rather than a source and conduct of knowledge.

Recently Shrivastava and Shrivastava (2004) also addressed the main guiding principles of constructivism as posing problems of emerging relevance to students, structuring learning around primary concepts - the quest for essence, seeking and valueing students' point of view, adopting curriculum to address students' suppositions and assessing student learning in the context of teaching.

The development of constructivism is discussed in the above paragraphs. It was found that the trend has changed from behaviorism to constructivism i.e
construction of knowledge on one's own, based on the preexisting knowledge. In the initial stages knowledge was considered as a commodity that can be transplanted into pupils' minds. But gradually the idea has changed and it is felt that an individual builds knowledge during the process of learning. It may be individually on their own or by interacting with others.

### 2.2 Studies related to the characteristics of constructivist teaching and learning process.

Constructivism is a view of learning based on the belief that knowledge is not a thing that can be simply given by the teacher at the front of the room to students in their desks. Rather, knowledge is constructed by learners through an active mental process of development; learners are the builders and creators of meaning and knowledge. Constructivist beliefs have recently been applied to teaching and learning in the classroom. Constructivism draws on the developmental work of Piaget (1977) and Kelly (1991).

Fosnot (1989) defines constructivism with reference to four principles: learning, in an important way, depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than mechanically accumulating facts; meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas. A productive, constructivist classroom, then, consists of learner-centred, active instruction. In such a classroom, the teacher provides students with experiences that allow them to hypothesize, predict, manipulate objects, pose questions, research, investigate, imagine, and invent.
Yager (1991) suggested the procedures for constructivist teachers namely challenging the students' previous conceptions, encouraging spirit of questioning, thoughtful discussions, autonomy and initiative among the students. The students are to be encouraged to use manipulative, interactive physical materials and explore the things surrounding them. In addition to the above features emphasis of social qualities like promoting student leadership, collaboration, location of information and taking actions as a result of the learning process; encouraging use of alternative sources for information, predicting consequences of the events; providing adequate time for reflection and analysis; respecting and use all ideas that students generate; encouraging self analysis, collection of real evidence to support ideas and reformulation of ideas in light of new knowledge were suggested. Brooks and Brooks (1993) and Clemens (2001) also suggested the characteristics of a constructivist teacher. Apart from the suggestions given by Yager (1991), it was reported that as a result of constructivist classroom there is cognitive and affective growth, improved tolerance, civility and understanding. Students learned to value multiple perspectives, validate their own ideas and to be respectful of others and their ideas.

In turn Brooks and Brooks (1993) also offered an interesting comparison of the visible differences between "traditional" classroom and "constructivist" classrooms. They compared the curriculum transaction, role of teacher in the class, value placed for the students, assessment point of view and so on. They had also expressed that the students are encouraged to develop meta-cognitive skills such as reflective thinking and problem solving techniques in the constructivist approach unlike in the traditional method of learning.
In addition to the ideas of Brooks and Brooks (1993), Insley and Lynn (1998) conducted a qualitative study of 8th grade students and their experiences in constructivist English teachers classroom. Participant observations and informal and formal interviews were key research strategies. The findings indicated that there were five significant factors the eighth graders thought were important to learning. They were: i. creating and building positive learning environment. ii. acknowledging is natural learning process. iii. connecting of previous learning to current meaning making experiences. iv. providing ongoing opportunities for students to express their unique abilities and to display their meaningful learning and v. using small learning groups that allow for natural social process. Offering the students perspective on learning adds a powerful dimension to the literature on constructivist teaching and learning.

Constructivist teaching and learning were the focused areas of research of Gray. In his research an insight was provided into the process of teacher change and development and raised questions about teacher professional development that had implications for the way constructivist and transactional curricula are implemented. There were philosophical and psychological arguments to support constructivist educational practices (Perkins, 1999). Philosophically, the individual has to construct or reconstruct what things mean because the stimuli we encounter are never logically sufficient to convey the message. Psychologically, research shows that active engagement in learning may lead to better retention, understanding and active use of knowledge.
Appleton (1996) conducted a study and explored a way to analyse and describe learning derived from both constructivist theoretical and classroom practice. This study resulted in a model for science lessons, which allows identification and description of students' cognitive progress through the lessons. By using this focus on the learner, it provides pre-knowledge for teachers about students might arrive at solutions to science problems during lessons and therefore potentially indications about appropriate teaching strategies.

Yager (2000) summarizes the characteristic features of Constructivist approach as follows:

*Constructivism emphasises learning and not teaching; encourages and accepts learner autonomy and initiative; sees learners as creatures of will and purpose; thinks of learning as a process; encourages learner inquiry; acknowledges the critical role of experience in learning; nurtures learners natural curiosity; takes the learner's mental model into account; emphasises performance and understanding when assessing learning; bases itself on the principles of the cognitive theory; makes extensive use of cognitive terminology such as predict, create and analyze; considers how the student learns; encourages learners to engage in dialogue with other students and the teacher; supports co-operative learning; involves learners in real world situations; emphasises the context in which learning takes place; considers the beliefs and attitudes of the learner; provides learners the opportunity to construct new knowledge and understanding from authentic experience.*
The goals for science education suggested by National Science Education Standards (NSES) (NRC 2000) is to develop students who know about and understand the natural world. They can use scientific processes and principles to make decisions and should be able to engage in discourse and debate of issues related to science and technology. Finally, there is a need to develop in students the knowledge and skills of science.

Yagnik and Likhia (2004) gave a clear understanding in constructivist approach. They also gave a brief account of shift from behaviourism to cognitivism and then to constructivism, the historical movements in the teaching learning process and also listed down the major points of constructivism as: i. prior beliefs; ii. conceptual change; iii. validity of self-constructed conceptualizations; iv. cognitive disequilibration and v. inquiry.

Stevens (2004) explained the influence of behaviorism and constructivism. The research findings suggested that there are three factors which characterizing the constructivist learning situations in the classrooms. They are i. student autonomy ii. classroom interaction iii. cognitive exploration leading to higher order thinking skills.

Senapathy (2004) attempted to integrate digital technology into constructivist learning environment for effective learning and expressed that constructivist revolution offers a new vision of the learner as an active sense maker and suggested new methods of instruction.
The studies reviewed above focuses on characteristics of constructivist approach, constructivist teachers, suggestions for the teachers following the constructivist approach, description of classroom, and constructivist classroom environment.

2.3 Studies related to the effectiveness of constructivist approach on teacher education and other subject areas

There are a number of studies conducted on attitudes, beliefs, views and behaviour of the teachers (Elaine, 1996) in a constructivist classroom. Especially many researches have been carried out on the issues related to planning and teaching science and the role of teacher from a constructivist perspective. Scot, P., Asoko, H., Driver, R. et al. (1991) drew attention to the following four aspects of constructivist teaching. i. There is no unique method or instructional route for teaching a particular topic from a constructivist perspective. ii. Learning science involves not only coming to terms with new conceptual structures but also involves developing a new rationality for knowledge. iii. The teaching involves establishing an argument for the science view which is likely to involve empirical findings but goes beyond these in helping students to construct the particular 'ways of seeing' adopted by the science community. iv. Teaching informed by a constructivist perspective recognized that both the practical activities and their discussion might be interpreted by students in ways that differ from those of intended.

There was a concentrated effort by Chaille and Britain (1991); Tobin and Dawson (1992); Tolman and Hardy (1995); and Louise, S.E. (2000) in studying the
role of a teacher in constructivist approach. It was pointed out that in a constructivist classroom, the teacher is no longer the transmitter of knowledge but the facilitator of learning (Tobin and Dawson, 1992). The facilitator of learning needs to keep in mind that instruction will vary depending on the learners' prior knowledge (Tobin and Dawson, 1992), current interest, and level of involvement (Chaille and Britain, 1991), acquiring, understanding, using and reflecting on knowledge (Tolman and Hardy, 1995). Louise (2000) examined the role of a teacher study group in negotiating constructivist science teaching in an elementary school. The study group created a non-threatening forum for reflection, support and sharing as each teacher learned she is not alone in the struggles and challenges they experienced in negotiating constructivism and the new science curriculum.

In connection to the above studies, Steffe and D'Ambrosio, (1995) also explained the importance of activating prior knowledge by teachers. They expressed that when teachers are familiar with students' prior knowledge they can provide learning experiences to build on these existing understandings. Prior knowledge can be activated in many ways for example, by asking students what they know, by brainstorming, by doing semantic mapping, by predicting outcomes or by performing some skill or process. Gurney (1995), Shchlenker, Yoshida and Pery (1995) also stated that articulation of prior knowledge acquaints teachers with students' thinking, affording insights from which to plan instruction. To bring out changes in the students learning, teacher's knowledge is constantly being constructed as he or she interacts with students (Simon, 1995).
Students must activate prior knowledge in order to extend and refine this knowledge. The most effective activities for knowledge use are problem-solving activities (Steffe and Gale, 1995). This encourages students to continue to examine and build on their knowledge. When students work in groups to solve problems, it is more useful than when they work alone because they have the opportunity to constantly voice ideas and receive feedback (Chaille and Britain, 1991). Reflection refers to understanding what one knows. This requires providing activities that ask students to look back at what they have learned (Tobin and Dawson, 1992).

Research indicated that communicating knowledge is essential for understanding (Fensham and Gunstone, 1994). There are many ways in which knowledge can be shared for example, conferencing between teacher and student, small group activities in which students voice their interpretations, oral reports, projects, role-playing and demonstrations.

A study conducted by Glynn and Duit (1993) expressed that in order to help students learn science meaningfully; teachers should ensure that learning is constructive. The constructive learning of science is a dynamic process of building, organizing, and elaborating knowledge of the natural world. In their view, students learn science meaningfully when five conditions are present: (i) existing knowledge is activated, (ii) existing knowledge is related to educational experiences, (iii) intrinsic motivation is developed, (iv) new knowledge is constructed, and (v) new knowledge is applied, evaluated, and revised. Students vary in the nature and extent of their experiences and therefore come to science class with personal mental models that vary in the degree.
A few studies were conducted to examine the beliefs, attitude, support and usage of constructivist practices by the preservice and inservice teachers in the west (Tobin and Dawson, 1992; Beard, 1995). Joseph (2000) designed a qualitative study of the beliefs and practices of a group of effective middle school teachers with respect to constructive learning and teaching environments. The results clearly showed an evidence of correlation between the beliefs and practices found in constructivism and what effective middle level learning and teaching environments. Constructivists are more conscious of the role of both student and the teacher in affecting cognitive development in students.

John, S.T. (2000) in his study measured the teaching behaviours of elementary science teachers. The results of the study indicated that the teacher who understood constructivist-based science scored significantly higher on most of the CLES (Constructivist Learning Environment Survey) scales. This study allowed one to predict that a teacher who understands constructivist-based science may practice this form of pedagogy more often than a teacher who does not. According to this research, elementary teachers may avoid constructivist-based science teaching due to a lack of understanding rather than a limited time for support from principal, staff or peers.

Youngsun (2001) also investigated the pre-service teachers' understandings of the ontology and epistemology underlying constructivist notions of learning. Of the sixteen participants in the study, five significantly changed ontological and epistemological beliefs and eleven did not. Profile changes for the five who did
change also resulted in changes in their conceptions of science teaching and learning. The overall conclusion drawn from this research is that pre-service teachers can develop constructivist notions of teaching that are consistent with and founded upon philosophical principles.

Palas, Denise D. (2002) in his interpretive research project examined how teachers' beliefs and attitudes about learning related to their work as mentors to student teachers. Mentors were found to embrace a non-linear, multidirectional view of learning in which learners made choices and decisions and in which teachers valued their autonomy to structure classroom time in ways that supported beliefs about active child centred learning. Finally, a theme emerged depicting the struggle participant mentors felt as their student teachers entered the teaching field.

Later the research focused on usage of constructivist approach in the area of teacher education. Tobin and Dawson (1992) developed a teacher survey and a student survey to determine the frequency of usage of various instructional practices by the teachers. Overall, teachers reported significant improvements in the science and mathematics curricula. The findings of this study provided evidence that; i) teachers feel the science and mathematics curricula are much more adequate since the implementation of the systemic reform process, ii) teachers report using a variety of constructivist strategies in their classrooms (weekly or more often) and iii) students also report experiencing constructivist practices in their classrooms. Overall, teachers and students report using several constructivist practices in their classrooms. Moussiaux and Norman (1996) also supported the above findings.
Wing-Mui SO (2002) conducted a study that aimed to find to what extent constructivist teaching was utilized in primary science lessons. The evaluation approach used during the lesson observation pertained to a constructivist view of teaching and learning. A more detailed analysis of student teachers' performance in the six areas (of features of constructivist teaching) showed that the overall performance of student teachers in the six areas of features of constructivist teaching was moderate. Student teachers during their microteaching paid some consideration to learners' prior understanding in their teaching. Comparatively, student teachers were able to: use pupils' existing knowledge to guide teaching and devise incisive questions; provide opportunities for pupils to utilize ideas and guide pupils to generate explanations; and, alternative in a micro-teaching setting. They made frequent use of questioning to guide learners to understand new ideas. However, student teachers seemed quite satisfied with the short answers provided by learners and they seldom required learners to further elaborate on their responses.

Beard (1995) conducted a study to determine the extent of support for the new paradigm among secondary science teachers. The results of this study indicated a moderate support for the constructivist paradigm. It was found that constructivist assessment principles received less support than the teaching and learning of constructivist principles. Results of multiple regression analyses revealed gender and type of science class as having significant relationship with science teachers' perceptions of the constructivist principles. Females were significantly more supportive of the constructivist principles than the males.
In nineties the focus of constructivist approach had broadened. Number of studies were conducted to see the impact of constructivist approach on teacher education.

Terrance (2001) conducted a study to find out the effects of traditional and constructivist teaching methodologies on comprehension of content of an acids and bases chemistry unit in 7th grade. A content-based assessment, with a conceptual understanding component was administered at the end of the instruction and also after three weeks to test long-term memory retention. The findings seemed to indicate improved comprehension among students and improved pre-service teachers' attitudes toward teaching and learning mathematics and science. The findings of the study also speak of the need for a constructivist approach when longer-term retention is the goal.

It was also reported that constructivist teaching methods improved pre service teachers' perceptions (Moussiaux and Norman, 2000; Steffe and Gale, 1995); attitudes toward mathematics and it also helped them learn mathematics (Appleton and Asoko, 1996; Gibson, 2000) and in reducing anxiety level Couch-Kuchey (2002). A case study done by Appleton and Asoko (1996) to examine the impact of an in-service programme about constructivist approach on teachers' progress, found that teachers who used constructivist approach had improved in their teaching attitudes and attitude towards science. Gibson (2000) reported similar results about the impact of constructivist instructional methods on pre-service teachers' attitudes toward teaching and learning science. He also expressed that this method of
teaching had a positive impact on pre service teachers’ attitude towards mathematics (Gibson, Brewer, Magnier, McDonald & Van Strat, 1999). In addition, the data indicated that these instructional methods also helped preservice teachers learn mathematics.

A case study conducted by Sook (2001) also indicated that there was a positive impact on preservice teachers' understanding of physical science concepts, attitude towards science teaching and learning. It was reported that there was improvement in critical thinking skills among middle school teachers. On the contrary, principles of biology taught using a traditional approach (lecture and note taking) had a negative impact on preservice teachers interest in teaching science (Gibson and Van Strat, 2000).

Apart from the improvement in the perceptions and attitudes it was reported that the teachers were able to prepare various assessment prototypes to prototype higher level thinking among students as a result of constructivist approach (Daigle, Marie A, 2000). Participants in the study indicated improvement in their ability to apply constructivist principles to their standards-based classrooms.

In Indian context, Donga (2004) had investigated the theoretical and practical constructivist view of secondary school teachers. One hundred and eighty seven secondary school teachers were selected as a sample for the study. The analysis of the data revealed that (i) There was no sex difference in theoretical constructivist view of teacher as well as practice of constructivism by school teachers. (ii) There was no significant effect of teaching experience, educational qualification and
professional qualities of teachers on their theoretical constructivist as well as on their use of constructivism in the practice of teaching. (iii) Most of the teachers were found to be believing in constructivism theoretically and were practising them in classroom.

Certain studies were conducted to examine the relationship between teachers' personal beliefs about how students learn mathematics and their instructional practices with regard to the mathematical achievement of secondary level students in United States (Jane, 2000). The findings suggest different dimensions of teachers' beliefs and instructional practices have differing effects on student achievement.

Yuen (2001) conducted a study to develop the constructivist behaviours among four new science teachers prepared at University of Iowa. The results indicated that the new teachers were largely early constructivist teachers. The new teachers shared arrange of constructivist behaviours that correspond to national standards including (i) students sharing the responsibility of learning with teachers; (ii) student engagement in activities and experiences; (iii) students with positive attitudes who are motivated to learn; (iv) teaching that focuses on student relevance; (v) variation in teaching approaches and assessments; (vi) establishing a friendly, non judgmental learning environment; (vii) teaching that incorporates higher order thinking skills and the use of scientific knowledge and ideas; (viii) teacher understanding of subject matter and integration of content and science process skills in context; (ix) teacher as intellectual, reflective practitioner.
Heeyoung (2001) conducted a study to determine whether the present Korean teacher education programme for secondary school teachers was effective in improving teacher understanding of constructivism and STS because the current Korean National Science Curriculum emphasized both ideas as reforms. After the treatments in the pre service and in service teacher education programmes, the teachers were inclined to agree with ideas of constructivism and STS. Pre service programme was more effective than that of in service programmes in improving teachers’ perspectives of both constructivist and science technology and society (STS).

Watts and Fofili (1998) explained the notion of 'constructivist teaching' and discussed as it featured within the debates on constructivist research in science classrooms. An argument was then made that constructivist teaching itself should be superseded in favour of 'critical constructivism', an approach which undertakes a broader critique of the relationships between teacher and the taught, between learner and subject matter and between schooling and society. Some data was also presented in this article from a study of Brazilian teachers moving from constructivism towards critical constructivism through an in-service professional development course and a series of action research projects.

James, D.M. (2000) explored the learning-to-teach process of four first-year high school teachers, all graduates of a constructivist-based science education program known as Teacher Education Environments in Mathematics and Science (TEEMS). The pedagogical perspectives apparent among the participants in this
study emerged as six patterns in teaching method: (i) utilization of grouping strategies; (ii) utilization of techniques that allow the students to help teach; (iii) similar format of daily instructional strategy; (iv) utilization of techniques intended to promote engagement; (v) utilization of review strategies; (vi) assessment by daily monitoring and traditional tests and vii. restructuring content knowledge.

Michael, J. (2001) examined the theoretical discourse over constructivism in education and empirically studied the shift in one teacher's praxis as he moves from individual constructivist pedagogy to social constructivist pedagogy. Two significant dilemmas appeared through study of discourse and practice of social and individual forms of constructivism. First, taking constant stance towards teaching can create an illusion for a teacher committed to discipline based pedagogy. Secondly the empirical study raised questions about the enterprise of reading in constructivist classrooms.

Geelan (1995) in his study expressed that number of different, flexible strategies must be combined if curriculum development is to be truly constructivist in its perspective; there is no single 'right way'. Matrix technique is offered as one possible way of organizing the ideas, knowledge, discussion and inquiry of students in science classrooms, with the intention of promoting the individual and social construction of viable knowledge. Its particular contribution is seen to be in the area of facilitating the critical synthesis of ideas of students from a variety of disciplines in seeking solutions to relevant, motivating problems from the human world. The introduction of constructivist reforms should ideally occur through
meaningful negotiation of both (i) the learning environment and (ii) ideas about knowing and learning with students.

Harcombe (2001) breaks new ground demonstrating that when professional teacher development is based on constructivist learning theory and framed in the knowledge domain of the sciences, it empowers teachers to dramatically change what they know, how they teach, and what their students learn.

Saunders (1992) proposed a four-step constructivist approach to teaching science; Hands-on investigative labs that are problem centred and where there are no prescribed methods or procedures to solving the problem or exploring the phenomena. Firstly, in using this inquiry approach students formulate expectations about what is likely to be observed. Secondly, there is active cognitive involvement - learning is made meaningful through activities like thinking out a loud, developing alternative explanations, interpreting data, participating in cognitive conflict and development of alternative hypothesis. Thirdly, students work in small groups - this stimulates a higher level of cognitive activity among larger numbers of students than listening to lectures and also there are expanded opportunities for cognitive restructuring. Lastly, there is scope for higher level assessment of hands-on investigation, cognitive involvement and group collaboration.

Lyons, Carol A (1996) reported the activities in which the teacher leaders engaged during session on the constructivist approach during the 1996 Teacher Leader Institute. The authors outlined five principles of learning that provided a framework for the session and discussed how participants constructed an
understanding of leadership. The characteristics of positive demonstration lessons identified by participating teacher leaders were given. Finally, constructing a plan of action was discussed and a 10-point plan of action developed by small groups of teacher leaders was presented.

Zeigler (2000) examined the relationships between the perceptions of constructivist practices contained in the National Education Longitudinal Study of 1988. The findings suggested that different dimensions of constructivist teaching, learning and supervisory practices have differing effects on student achievement. The results confirm research supporting positive effect of constructivist learning practices. Specifically, an emphasis on problem solving was positively related to student achievement in mathematics. The results of the study also suggested that school setting, mathematics certification, teaching experience, gender and minority status are all factors related to the use of constructivist teaching, learning and supervisory practices.

Sanf-Chong (1998) conducted a study on teacher understanding of the nature of science and its impact on student learning about the nature of science in STS/constructivist classrooms. The results indicated that students who were taught by STS/constructivist teachers with high TOUS scores moved toward "congruent" views concerning the nature of science on a number of VOSTS items. Also students who were taught by more traditional teachers with low TOUS scores moved toward "naive" views. The findings supported the fact that teachers who know more about the nature of science and who practice many of the STS/Constructivist teaching strategies assist students in learning more about the nature of science.
Freedman (1998) conducted a study on constructivist assessment practices. Varieties of assessment practices wherein students were given multiple opportunities to show their competence were included. Alridge, Fraser and Taylor (2000) undertook a study to validate and use constructivist learning environment scale (CLES) in Chinese and English version.

Scricco, et al. (2000) conducted a study to help the foreign language teachers understand the importance of constructivist theory in education and how this pedagogy has helped to make computer integration possible in all disciplines.

Gold (2001) conducted a study on the impact of constructivist approach to online training for online teachers, examined the pedagogical role of the teacher in online education. This study investigated a two-week faculty development pedagogical training course aimed at preparing teachers to operate effectively within the online environment. The findings of the study are: (i) Online distance learning courses encourage more student participation than traditional face-to-face course. (ii) In online distance learning courses teachers and students can produce learning outcomes better than traditional face-to-face course. (iii) Online distance learning courses have more student-to-student interaction than their counterparts. This result validated the other studies on faculty views towards extrinsic versus intrinsic rewards.

Allen (2001) using an eight month, quasi-fieldwork approach and depth interviews examined how the staff of pioneer station high school constructed personal meaning for a decade long district initiative to restructure their school
using outcomes-based education. The study recommended that administrators rethink the traditional, single-reality, cause-effect world view and consider a constructivist worldview that supports the existence of multiple realities, multiple paths to understanding, and the possibility of influencing rather than directing change. It outlined a framework for constructing a better understanding of the change process, and it cautions administrators to respect the power of the culture of their schools.

Constructivist approach was tried out in various areas apart from teacher education. It was noticed that many studies were conducted to find the effectiveness of constructivist approach on mathematics and language learning (Pena-Perez, Beatriz 2000). One among them was the study conducted by Kim (1994) found that students in constructivist-mnemonic classes appeared to have a better understanding than the other students. Females retained significantly than their counterparts.

Research in the area of mathematics education revealed that constructivist-based instructional programme improved achievement and problem solving ability among the students (Smith, 1997). In contrast to the above findings, Volney (2002) in their study found that behaviourist group significantly outperformed the constructivist group on both subscales on both the immediate and delayed posttests. But the attitude scales revealed no significant differences in pretest posttest scores (Gray, 1994; Grigoruk, Melissa Sue Wright (1997). Added to these findings Reynolds, Theodora H. (1995) had undertaken a project to address gender issues
in mathematics classroom. The results showed a significant difference in the gender and cognitive issues in the mathematics classroom.

Apart from the above findings, constructivist approach also has significant impact in promoting change in students across all classes and groups. (Kretschmer, 1995; Herman, 1995). Added to this it was also revealed that constructivism advocated play as the centre of early childhood curriculum (Levin, 1996).

Janice (2000) conducted a case study focused on the voice of the child as he/she developmentally and cognitively constructed meaning from the beginning of written pieces to the end. It was assumed that the sense of constructivism in the prior knowledge and meanings were created by the learner in response to encounters with ideas, people or things and art brought by the student of the learning situation. Some of the findings were: i. Children build on positive and negative experiences in their lives and use portions of these at various times in their written work. ii. Children require time to express thoughts to other adults or peers because it helps them to put their framework of ideas into a writing perspective. iii. Children imitate, writing that is modelled for them. iv. Some who do not have teaching experience in their life rely on imagination. v. Teachers attitudes affect the final product of the child.

It was found that the principles of constructivist approach were also successful in music teacher's class (Chi-Der, 2000) and also in a national movement towards "Open education" (Minho, 2001).
The studies reviewed above in this section attempted to examine the attitudes, beliefs, views, behaviour and use of constructivist approach in the classroom by both preservice and inservice teachers. Some of the studies have also explored the difference between constructivist classroom and a conventional classroom and also the role of teachers in a constructivist classroom. Few researches also evidenced the improvement of preservice and inservice teachers perceptions, attitudes towards mathematics and science and reduction of their anxiety level as an effect of constructivist teaching methods.

2.4 Studies related to the effectiveness of constructivist approach in science education.

An old adage states, "I hear and I forget, I see and I remember, I do and I understand" (Woolnough, 1994; p.25), which seems to sum up, from a pupil's perspective, difficulties that might be associated with science learning.

Teaching science through investigation improves the students' achievement, their attitudes towards science; mastery of science process skills; problem solving; and creativity (Shymansky, Kyle, and Alport, 1982). While "hands-on" activities can devolve into closed-ended recipes (Walberg, 1984), true open-ended inquiry can more closely approach the notion of "minds-on". Cobern (1996) argued that science education research and curriculum development efforts in non-western countries could benefit by adopting a constructivist view of science and science learning. Constructivism offers a very different view of science and science learning assuming that the logical thinking is an inherently human quality regardless of culture
and instead focuses attention on the processes of interpretation that lead to understanding. Constructivism leads on to expect that students from different cultures will have somewhat different perspectives on science.

Sahlstrom and Lindblad (1998) addressed two questions: how is student work constructed in the science classroom and how are students' science lessons related to the construction of their school careers. Using a lesson on magnetic fields as a case analysis the study reported large differences between the lessons of the two focused students in terms of opportunities for learning both about science and about their social identities. The differences found between the two girls in terms of the development of their grades and their social networks in the class seemed to be closely mirrored in the classroom interaction.

Regina (1996) also conducted a study sought to determine the effects of prior knowledge and instructional patterns on academic achievement of 9th grade students (Ausubel, 1960; Tharp and Gallimores, 1988; Flick, Dickinson and Lederman, 2000). The findings of the study were: i. There was a significant difference in academic achievement were found between students with low and high prior knowledge; ii. There was a significant difference in meta-cognition between students with low and high prior knowledge levels; iii. There was no significant interaction was found between prior knowledge levels and instructional patterns on the academic achievement of students in global studies.

Related to the above findings, it was also found that during the process of construction of knowledge, there is a change in schema structure. It is explored in
the study conducted by Ismael (1999). He investigated the schema structure of students for human evolution, their idiosyncratic conceptual change after visiting a museum exhibition, the role of alternative frameworks during learning, and the function of affect in learning. The research findings provided evidence for museum exhibition developers to embrace a schema-constructivist theory of knowledge and learning in the creation of exhibitions, which actively engage the learner in conceptual change.

Added to the above findings, Baker and Piburn (1997) investigated the process of constructing science in middle and secondary school classroom. It was reviewed by Harris (1999) who discussed about how to bring about constructivist learning in a classroom. It was said that constructivist education requires that the learners' prior knowledge be taken into account from the outset - telling them what is correct, just doesn't work. Instead show them generate those insights in the minds of our students. Textbooks reduce science to its least common denominator on lecture format teaching. Any dialogue that takes place within a single voice is no dialogue at all and is inconsistent with the constructivist perspective.

Research was carried out to compare the student's epistemological beliefs of constructivist versus objectivist learning situations by Windschitl and Andre (1998). The constructivist approach resulted in significantly greater conceptual change than the objectivist approach for 2 of 6 commonly held alternative conceptions; the other 4 of 6 areas showed no significant differences for treatment group. The treatment interacted significantly with epistemological beliefs. Individuals with more advanced
epistemological beliefs learned more with a constructivist treatment; individuals with less developmentally advanced beliefs learned more with an objectivist treatment.

Related findings occur in research conducted by Ibrahim (2001) examined the impact of the guided constructivist teaching method on students’ misconceptions about concepts of Newtonian physics. The results of the study indicate that i. Guided constructivist group had significantly higher means than the other group. ii. Significant relationship was found between achievement, conceptual structures and beliefs about content. iii. No statistically significant difference was found between the two methods on achievement of males and females. iv. Greater conceptual learning was fostered when teachers use interactivity based teaching strategies.

Besides this, Richmond and Striley (1996) conducted a study to understand the process by which students solve scientific problems, the difficulties students encounter in developing the requisite pieces of scientific arguments while negotiating their social roles and the ways these roles shape task engagement and the development and articulation of the arguments themselves. The results demonstrated not only that knowledge building involves the construction of scientifically appropriate arguments but that the extent to which this knowledge building takes place depends on students learning to use tools of the scientific community; their expectations about the intellectual nature of the tasks and their role in carrying these tasks out; and the access they have to the appropriate social context in which to practice developing skills.
Hand, Treagust and Vance (1997) investigated the issues related to curriculum implementation, pedagogical skills and the processes of social construction of knowledge extensively for a period of 4 years. They examined students' perceptions of the changing nature of the secondary science classrooms as a consequence of the implementation of constructivist approaches. The results of the study indicated that the students were not only appreciative of the opportunity to use their own ideas and knowledge but were also aware of the changing roles and responsibilities required of them within the classroom. It was also indicated a clearer understanding of group interactions needed to be developed in terms of developing social construction of knowledge as a more powerful learning approach.

In most of the following studies, a control group of students were exposed to traditional methods of science instruction, while the experimental group of students were exposed to constructivist methods of science instruction (Terrance, 2001; Brass and Jobling, 1992; Ann, 2000; Janet Hatley, 1999; Chun-Yen and Song-Ling, 1998; Banet, 1997, Ertepinar and Geban, 1996; Kim, 1994; Carey, Susan and Smith, Carol, 1993; Geban, Askar & Ozkan, 1992; Gibson, 1998; Jaus, 1977; Mattheis and Nakayama, 1988; Padilla, Okey and Garrand, 1984; Purser and Renner, 1983; Saunders and Shepardson, 1987; Scheider and Renner, 1980; Selim and Shrigley, 1983; Shrigley, 1990; Wheatley, 1990; Wollman and Lawson, 1978). In all these studies it was concluded that inquiry-based science activities have positive effects on students' science achievement (Kim, 1994; Banet, 1997) and attitudes toward science and school, cognitive development, laboratory skills, science process skills and understanding of science knowledge as a whole when compared to students taught using a traditional approach.
Added to the above studies, Jeanne (1999) in their study explored that constructivist approach was also effective in developing students sense of self, social aspects and academic aspects. Later Caprio (2000) also offered many personal insights on his perception of student learning. The students in the constructivist group seemed more confident of their learning and he gave them more material for independent learning. It was also found that the students in the constructivist class seemed to like class better, had more energy and took more responsibility for their learning.

Similar findings were obtained by Foxx et al. (2001). They examined the influence of constructivist pedagogy on critical thinking skills, science fair participation and level of performance. It was found that participation in science fairs and constructing a science project helped students to develop the attitudes, skills and knowledge that helped them to be comfortable and discovering the nature of science. Blunck & Yager (1990) also in their investigation found that students in classes taught with a constructivist approach are able to develop more science creativity skills, positive attitudes toward science, understanding of the nature of science and accurate perceptions concerning science careers when compared to students in classes taught with a textbook-oriented approach.

The study conducted by Hatley (1999) also reported change in the cognitive development as a result of constructivist approach. In contrast to the findings of the studies reported above, in this study neither group showed significant changes in attitudes toward science over the course of the semester. Both groups demonstrated gains in content knowledge; the gain in the experiment group was
significantly greater than the gain in the control group (Hanley, 1994). At risk students in the experimental group exhibited significant gains in content achievement and logical thinking. Similar to the above findings the study conducted by Terrance (2001) found out the effects of traditional and constructivist teaching methodologies on comprehension of content of an acids and bases chemistry unit in 7th grade. It was found that constructivist approach was effective in improving comprehension and longer-term retention.

In contrast to the above findings, Sherri (1995) in his study examined the effects of a constructivist-learning environment on student cognition of mechanics and attitude towards science compared to students enrolled in a traditional lecture course and found that even though there were no significant differences in the two groups, qualitatively students said they enjoyed the constructivist strategies; instructor interaction, hands-on-activities and applications to everyday life.

Anyanechi, Carolyn, M.E. (1996) also investigated the use of a constructivist model to teach science to senior secondary school students in Nigeria. The treatment group was encouraged to work in groups using the local materials and in all other deliberations. The use of a constructivist model created a better and broader experiencing environment and understanding. The findings of the study not only proved the effectiveness of constructivist model but also suggested different approaches to science teaching. It was also revealed that the familiar instructional materials might have had contributed to enhancing students' cognitive styles.
Fouad (2000) explored the effects of constructivist approach using computer projected simulations and interactive engagement methods on senior secondary level i.e. 12th grade students. The results showed that there was marked improvement in understanding of Newtonian mechanics and on attitudes towards physics. It was also revealed from the result of the study conducted by Thomas (1996) that constructivist-learning environments had positive impact on motivation along with achievement.

Adams (1997) investigated the relationships between student beliefs about the nature of science, student attitudes and conceptual change about the nature of forces with in a traditional and within constructivist high school physics classroom. In the constructivist classroom (i) students saw physics as relevant and useful; (ii) there was no difference in worldview or agreement with the teachers' views on the nature of science between high and low conceptual change students; (iii) students appreciated the importance of empirical evidence and (iv) low conceptual change students had low classroom engagement. In this study it was found that the students taught by constructivist model have perceived science as relevant and useful to every day experience and also appreciated the importance of empirical evidence. Banet and Nunez (1997) made use of constructivist approach in teaching and learning about human nutrition for students of secondary education. The results showed how most of the students participated in this programme reorganized their ideas concerning the nutritional process and achieved a fuller understanding of process of nutrition in humans. The students taught by conventional method based on the teacher explanation and textbooks tended to have erroneous or incomplete ideas concerning the nutritional process.
Pooran (2000) examined the use of approaches to teaching science based on two contrasting perspectives in learning, social constructivist and traditional and their effects on students' attitudes and achievement. With constructivist-based teaching, students showed more favourable attitude towards science as a subject (Blunck S. M., & Yager R. E. 1990; Larry D.Yore, 1997 and Latchman, 2000), obtained higher scores in class achievement, total achievement and achievement on the knowledge and application test. Students in the traditional group showed more favourable attitude towards school. Females showed more positive attitude towards the importance of science and obtained significantly higher scores in class achievement. No significant interaction effects were obtained for method of instruction by gender.

Preece and Baxter (2000) had done a survey of the superstitious and pseudo-scientific beliefs of 2159 secondary school students. Gender differences were found at all ages with females generally less sceptical than males. Many school students were very gullible.

Research evidenced that the constructivist approach was effective in fostering science process skills like observation, encouraging hypotheses and their testing and comparing. (Hyang-Lim, 1995) Added to this Brass and Duke (1995) also found that constructivist approach is effective in developing the science skills namely formulate a hypothesis, design an experiment to test the hypothesis, note changes which occur and to record their findings in some way, observe using the senses, measuring, estimating, classifying, interpreting the results and to draw conclusions and use of variety of research techniques in their investigations.
Supplementing the above findings, Hyang-Lim (1995) conducted a study with younger children to understand changes in a target child's reasoning about water dynamics, specifically draining and movement of water in tubes. The study is important in providing an analysis that demonstrates that children in water activities are not "just playing" but that when materials and interventions challenge children's reasoning; they do in fact make progress in knowledge and reasoning. Teacher interventions that promoted progress in reasoning included fostering observation of regularities, encouraging hypotheses and their testing, fostering comparisons and promoting consciousness of actions and reactions.

A quasi-experimental study conducted by Henry (1995) to see whether a constructivist-based approach to science instruction could help fifth grade students improve scientific literacy, revealed that students in classroom that used a constructivist-based approach to science instruction were able to frame research questions, recognize blind alleys, and use science ideas, processes and inquiry. With regard to creativity, students in the classrooms that used a constructivist-based approach to science instruction demonstrated autonomy, took advantage of serendipitous situations, used local resources and displayed diversity of projects. Students showed independence in conducting projects and positive feelings about science in class and outside of class.

Marie (2002) investigated and revealed that the study provides a strong support for a positive relationship between constructivist learning environment and student attitudes, but little support for a direct relationship to student achievement in Algebra.
and Biology. Multiple regression findings showed that neither overall constructivist-
learning environment nor standards-based teaching practices predicted
achievement in any of the content areas. Overall constructivist learning environment
and standards-based teaching practices were significant positive predictors of
student intrinsic value and learning strategies in all three content areas, after
controlling for student and classroom demographic variables. Overall both the
practices were also significant positive predictors of self-efficacy in Algebra.

Yore and Shymansky (2000) focused verification of the use of students'
perceptions and attitudes and teachers' self-report information as measures of
interactive-constructivist science teaching in elementary schools. The students'
perceptions of their teacher's teaching were slightly positive to positive (2.08-2.67),
while students' attitudes toward science learning were somewhat more positive
(2.19-2.63). Teachers' self-reported use of students' ideas, applications of science
to the children's world, and use of print resources were positive (3.63-4.07).
Significant (p £ 0.05) main effects in the ANOVAs were found for students' view of
constructivist approach, students' perception of use of literature in science, students'
attitude toward school science, students' attitude toward the nature of science,
students' attitude toward careers in science, and teachers' report of using print
resources.

Speering and Rennie (1996) found in their investigation that as students move
through school, attitudes to school in general, and science in particular, become
less positive. This paper reports on a longitudinal study, which mapped, from the
students' point of view, the transition between primary and secondary school in Western Australia. The study focused on the subject of science, and used both quantitative and qualitative methods. During the transition, there is a considerable change in the organisation of the school, the curriculum and the teacher-student relationship. Students in this study, especially the girls, were generally disenchanted with the teaching strategies used in their secondary science classrooms, and regretted the loss of the close teacher-student relationship of their primary school years. Their perceptions were that science in secondary school was not what they had expected, and this experience may have long term implications for their subject and career choices.

In the similar lines Lucas and Roth (1996) conducted a study which was designed to investigate the relationship between students' views of the nature of scientific knowledge and their own learning of physics, and the evolution of this relationship over time. Twenty-three students were enrolled in a physics course that emphasised laboratory work and discussions about the nature of science. Changes in students' views concerning the nature of scientific knowledge and of the science teaching and learning process, which were not always complementary, are described with the aid of a model. The findings of this research have direct relevance to the planning and implementation of science courses in which the development of understandings of the nature of science is an objective.

Salim (1997) investigated the effect of guided constructivism and expository instructional methods on the attitudes of students towards physics. The results
showed that the experimental group had significantly higher means than the control
groups on all criterion variables. A significant interaction was found between groups
and performance levels in the following cases: (a) criterion variable of attitude toward
physics; (b) views toward physics learning and (c) enjoyment of physics. This result
indicated that the low performing students among the experiment group had greater
gain in attitude toward physics than the high performing students in the same group.
On the other hand there was no interaction occurred between treatment groups
and gender which shows that in this study gender has no significance on attitude
towards physics. Significant interaction between treatment groups and cognitive
levels were found on the criterion variables of beliefs about physics as a process
of learning and enjoyment of physics.

Tsai (1999) conducted a study, which viewed STS instruction as a promising
means to help students' progress towards constructivist oriented epistemological
views of science. It was an experimental study wherein 101 Taiwanese female
10th graders were involved and the treatment was given for a period of eight months.
The results of the study indicate that STS group students at the final stage of the
study tended to have scientific epistemological views more oriented to constructivist
views of science than traditional group subjects. Student in-depth interviews
revealed that some STS group students as a result of STS instruction tended to
accept the theory-laden quality of scientific exploration and perceive the importance
of social negotiations in science community and cultural impacts on science.

A survey done by Lamar (2001) to examine 152 students' perceptions of
constructivist pedagogy indicated no significant difference in the perceptions of male and female, or higher and lower achieving students regarding constructivist pedagogy. There was significant difference in the perceptions of visual and tactile learners regarding constructivist instruction.

It is revealed from the above studies that investigative methods and inquiry-based science activities have positive effects on students' science achievement, attitude towards science and school. Many studies explored the effectiveness of constructivist approach on the improvement of laboratory skills, science process skills, understanding of scientific knowledge, development of sense of self, social and academic aspects and critical thinking among the students. Number of correlation studies have been conducted to see the relation between constructivist learning environment and achievement and attitude towards science.

2.5 Insights from review

Even though the constructivist philosophy is very old, research on its effectiveness in the field of education in particular is of recent origin. It is hopeful sign that research on constructivist approach is generally receiving due importance.

The overview of the researches related to historical development of constructivist approach and its effectiveness on teacher education, science education crystallized some of the issues and observations that may help in framing hypotheses, adopting quasi-experimental design and employing statistical techniques for analysis of data for the present study.
The studies carried out in section II and III were experimental, correlational, comparative and descriptive in nature. Preservice and inservice teachers were the focus of the studies. Certain studies conducted are of survey type on the beliefs, values, attitudes, behaviour and the role of teachers in a constructivist classroom. Constructivist principles were tried out on pre-service teachers and found that they have improved in their epistemological beliefs, attitude, understanding of nature of science and so on.

The result of review of related literature made clear that there is lot of research conducted on historical development of constructivism than on its practice. In considering about the effectiveness of constructivist approach on students, the studies reviewed in the west concentrated on the process of construction of knowledge, and on the importance of prior knowledge in learning and its contribution to increase achievement in science. Few of them investigated on students' epistemological beliefs, schema structure and development of curriculum and its implementation. The result of the reviewed studies indicated an improvement in achievement in science, science process skills and better attitude towards science as a result of constructivist approach. Many studies were conducted in physics and few had seen the impact on integrated science. Sporadically studies were conducted on impact of constructivist approach on scientific attitude.

Along with the above results it was also seen a clear understanding of concepts, long-term retention of knowledge acquired as a result to constructivist approach. Besides cognitive development, some of the studies revealed that constructivist
approach is effective in developing confidence, self concept, certain social aspects like building good relationship among students and between student and teacher and so on.

Some of the studies concentrated on the construction of tools in the context of constructivist approach like Constructivist Learning Environment Survey scale, scientific attitude, TOUS etc.

In Indian context, research in the area of science education concentrated on designing science curriculum, experimentation of models of teaching in science, use of computers in science teaching, and so on. Experimental studies were carried out to try out various models, methods and approaches in science. Number of correlation studies were conducted to examine the relationship among variables like achievement, attitudes, intelligence, gender and so on. Some of the studies were undertaken to assess the achievement level, and the attitudes of the students towards science.

It was clear from the review that there are numerous studies conducted on constructivism and its effectiveness in the area of teacher education, music, internet education, MBA programme in west. But in India it is yet to gain prominence not only at research level but also at awareness. It was also found that there were rarely any empirical studies done in India on constructivist approach in the area of science education.
Hence this study is taken up to find out the effectiveness of constructivist approach in improving achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science of secondary level students.

After having discussed the related studies and their implications to the present study the methodology followed in the study is being discussed in the next chapter.