

Chapter - 5

Summary and Implications

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SUMMARY AND IMPLICATIONS

5.0 Introduction

Technology has revolutionized our present society. In the last two decades Technology has dramatically reacted into every aspect of social and cultural lives. But at the same time Teaching and other Educational Endeavours have not taken full advantage of these changes. The schools have remained in the past, while our children are much ahead. In the Classroom we present our knowledge to our children in a linear, didactic manner that differs dramatically from the children's previous experience outside the School. For the children the school is rigid, uninteresting and ultimately alienating. The result is the mismatch between the learner and the educator. But it is not the children who are mismatch to the schools; rather the schools are mismatch to the children. This divergence between our children and our educational practices needs a drastic educational reform that will bring the classroom into line with society, only by renewing educational practices; we can close this gap and reunite our schools with our children and rest of the society. To achieve this, there is an urgent need of introducing Technology Aided Constructivist learning environment for the professional development of teachers. Teacher must know the most current research practice which can be used effectively to match particular teaching procedures. Such goals are not easy to achieve. It requires re-organization of the Pre-Service and In-Service teacher education programs as well as the school system keeping in view the new pedagogy and challenges of globalization. To accomplish this goal requires both a change in the traditional views of learning process and an understanding of how the digital technology can create new learning environment. In which students are engaged learners, able to take greater responsibility for their own learning and construct their own knowledge through the constructivist learning approach.

Constructivism suggests that the learner's understandings of the way the worlds' work is the result of one's own active construction rather than someone else's presentation. Constructivist believes that knowledge is the result of individual constructions of reality (Brooks, 1990). Constructivism is meaning making activity and produce active learners and creative thinkers. But now there is a widespread concern that the educational experiences provided in many schools are not preparing students well for

the future. It is believed that creating a paradigm shift in view of learning process, coupled with the application of technology may play an important role in bringing educational systems into alignment with the emerging knowledge based information rich and technologically advanced society. ICT offers wide array for building new schooling systems that allows long distance exchange and interaction between geographically spread groups of teachers and their students meeting this challenge, in turn requires collaboration across national, cultural, and institutional boundaries, and among groups and individuals who have been isolated. Electronic mail, bulletin board systems, teleconferences and virtual communities of World Wide Web allow reciprocal communication among individuals and groups with common interests. Our aim of educators must go beyond specialized training of craftsmen and factory workers. The only true education is one where all arts, crafts, sciences, technologies are linked and facilitate mutual cognitive development, productive creativity and personal growth. So at the time we need teachers who are masters not only in technology but also in content, pedagogy and above all they should be humane. Only technology and content cannot replace a teacher, the teachers must be well versed in child psychology, should have a capability to understand the children mental, physical, psychological situation and then apply technologies with the content and pedagogy.

5.1 Information and Communication Technology and Constructivist Learning Approach

ICT provide a more “open” learning opportunity, it will cater for more student-centered learning as oppose to “closed” learning opportunity that is more instructor-dependent (Ng, 2002). Thus Constructivism requires a teacher to act as a facilitator helping students become active participants in their learning and make meaningful connection between prior knowledge, new knowledge and the processes involved in learning.

Kulik and Kulik (1991), viewed computers as valuable tools for teaching and learning. Specifically, they claimed that Educational technology is capable of producing positive effects on student achievement, it could produce substantial savings in instruction time, it fostered positive attitudes toward technology, and in general, educational technology could be used to help learners become better readers, calculators, writers, and problem solvers. Technology had an actual impact on student learning and played an important role in student learning (Kozma, 1994).

In the past decade, a sudden resurgence of interest was markedly observed in the classroom use of technological innovations, along with the increased use of the Internet and other Digital Technologies (Reiser, 2002). The field of Instructional Design and Technology, too, saw the evolution and emergence of alternative approaches, such as cognitive and constructivist theories, that deviated sharply from traditional practices, such as behavioral models. New emphases, like electronic performance support systems, web-based instruction, and knowledge management systems, not only shook the knowledge base of the field, but also widened its horizon across business and industry, the military, health care and education, worldwide. Initiatives, such as situated learning theory and constructivism presented fresh approaches to bring about reforms in the domains of public education and higher education (Jonassen, 1999). A complementary relationship appears to exist between computer technologies and constructivism, the implementation of each one benefiting the other.

Technology, according to Jonassen, Peck, and Wilson (1999) refers to “the designs and environments that engage learners”. The focus of both constructivism and technology are then on the creation of learning environments. Likewise, Hannfin and Hill (2002) depict these learning environments as contexts: in which knowledge-building tools (affordances) and the means to create and manipulate artifacts of understanding are provided, not one in which concepts are explicitly taught... a place where learners work together and support each other as they use a variety of tools and learning resources in their pursuit of learning goals and problem-solving activities. Within this shift in focus from the objectivist to the constructivist context domain, technology can play an integral part in the learning environment. “The richness of the technology permits us to provide a richer and more exciting (entertaining) learning environment... our concern is the new understandings and new capabilities that are possible through the use of technology” (Duffy & Cunningham, 1996). By integrating technology with constructivist methods, such as problem-based learning and project-based learning, learners are more responsible for and active in the learning process (Grant, 2002). Additionally, everyday applications, such as word processors and spreadsheets, become powerful instruments for authentic learning. Constructivism offers flexibility to teachers to individualize learning for each student while using technology tools to

augment cognitive and metacognitive processes. Perhaps the most useful pieces of available technology for students are hypertext and hypermedia which allow students to browse information in a nonlinear fashion. These data bases contain hyperlinks which give the decision making power as to what to explore next. This type of interactive learning also allows the student to create his or her own nonlinear data bases! "Interactive learning in this context means learning in which inquiry, feedback and ongoing collaboration play important roles" (Barr, 1990). Strommen and Lincoln (1992) make the point that it is not what equipment is used, but how it is used that makes the difference. The key to success lies in finding the appropriate points for integrating technology into a new pedagogical practice, so that it supports the deeper, more reflective self-directed activity children must use if they are to be competent adults in the future. In other words, computers and other technology should not be viewed as "add ons," but as tools which are an integral part of a child's learning experience.

5.2 Information and Communication Technology Aided Constructivist Learning Approach for Pre- Service Teachers

According to NCTE framework (1998), Teacher Education is a professional programme aiming at the development of teacher as a person and agent of social change. The professional preparation of students who want to enter the profession of teaching, teacher education prepares them, for attaining the national goals of education for all, to preserve the continuity of traditions, to fulfil the actual needs of contemporary society, to meet the challenges of the uncertain future through education. Pre-Service Teacher Education develops better understanding of children, builds the confidence, makes them familiar about methodology of teaching with new techniques, builds positive attitude towards the teaching profession, familiarizes with latest knowledge of the profession, and develops attitudes towards research and experimentation. According to National Curriculum Framework (2005), reorienting the curriculum must be among our highest priorities, informing the information of teachers, the annual plans of schools, the design of textbooks, learning materials and evaluation patterns. The Yashpal Committee Report (1993), Learning Without Burden,

noted: “The emphasis in these programmes should be on the enabling trainees to acquire the ability for self-learning and independent thinking”. Teacher education must become more sensitive to the emerging demands from the school system, for this it must prepare the teacher for the roles of being an: encouraging, supportive and humane facilitator in teaching-learning situations to enable learners to discover their talents, realize their physical and intellectual potentialities to the fullest and to develop character and desirable social and human values to function as responsible citizens and active member of a group of persons who makes a conscious effect for curricular renewal so that it is relevant to changing societal needs and the personal needs of learners.

Teachers need to be prepared to view learning as a search for meaning out of personal experience and knowledge generation as a continuously evolving process of reflective learning, view knowledge not as an external reality embedded in textbooks, but as constructed in shared context of teaching-learning and personal experience, appreciate the potential of productive work and hands-on experience as pedagogic medium both inside and outside the classroom.

“Professional preparation and development goes beyond the term ‘training’ with its implications of learning skills and encompasses a definition that includes formal and informal means of helping teachers not only learn new skills but also develop new insights into pedagogy and their own practice and explore new or advanced understandings of content and resources”. Current technologies offer resources to meet their challenges and provide teachers with a cluster of support that help them continue to grow in their professional skills, understandings and interests. The role of classroom teacher is the crucial factor in the full development and implementation of technology and other pedagogy to be used. The transformation of classroom technology from hardware, software and connections into tools for teaching and learning depends on knowledgeable and enthusiastic teachers who are motivated and prepared to put technology to work on behalf of their students. A well developed professional development program is essential to reach the goal of preparing teachers for effective teaching.

Professional development of teachers is imperative to capitalize on the potential of new technology as a learning tool. Professional development should enable the teachers to construct professional knowledge about pedagogy, content and technology, as well as, strategies for managing the classroom involvements brought about by the creation of constructivist learning environment supported by technology. To achieve this, teachers should be given appropriate learning experiences. These experiences should be situated in an authentic context for teachers in their school and classroom. It should build on their prior knowledge and provide opportunities for social interaction with colleagues .It should begin with investigation of problems supported by technology that are relevant to teachers. Such learning experiences enable the teachers to create learning environment appropriate for children of the information age. ICT involved education helps the Pre-Service and In-Service teachers to become capable to the present competitive classrooms.

It is not easy to adopt ICT aided Constructivist Learning approach directly, for this teacher has to be prepared enough. In the constructivist classroom the responsibility of the teachers will be more. Teachers should be well versed in the knowledge and principles of constructivist approach. Here the knowledge is actively built, so teachers should provide the suitable learning environment like engaging students in learning, encourage group interactions. Teachers should nurture students' natural curiosity through frequent use of ICT, and provide the knowledge of ICT in various forms. So to achieve all these teachers must know the constructivist approach and ICT in order to teach to their students. When their support of ICT in the process of teaching, teachers also feel enthusiastic to teach and it will help to make the abstract ideas into concrete one. In order to achieve this teachers have to be trained well before, they need professional development programs regarding ICT and Constructivist approach. According to National Focus Group (2000), in Pre-Service Teacher Education there is a need to introduce use of media and technology-enabled methods of learning, making it inherent and embedded in the teaching-learning process of teachers, and to enable trainee teachers to access sources of knowledge and to create knowledge. It needs a paradigm shift and willing abandonment of familiar perspectives and practices and the absorption of new ones (Brookes, 1993). Teachers who are not familiar with the constructivist approach using ICT as tools may first require a change in the educational philosophy (Healy, 1998). So here in the present study ICT Aided Constructivist Learning Approach for Pre-Service Teachers has been emphasized.

5.3 Review of Related Literature

In the present study different studies related to the Constructivism, Information and Communication Technology Aided Constructivism, Constructivism in Science Education, and Information and Communication Technologies aided Constructivism for Professional Development of Teachers have been reviewed. In the present study the researcher has reviewed the theoretical literature which helps to thoroughly examine the corpus of theory that has accumulated with regard to an issue or phenomenon, it helps to find the theories already exist. The relationship between them and helps the researcher to build a framework for further research. When talking of the history of Constructivism, Brooks (1999), says “As long as there were people asking each other questions, we have had constructivist classrooms, Constructivism, the study of learning, is about how we all make sense of our world, and that really hasn’t changed.” The concept of constructivism has roots in classical antiquity, going back to Socrates’s dialogues with his followers, in which he asked questions that lead to his students to realize for themselves the weaknesses of their thinking. The Socratic dialogue is still an important tool in the way constructivist educators assess their students’ learning and plan new learning experiences. Dewey (1916) called for education to be grounded in real experience; inquiry is a key part of constructivist learning. Piaget (1926), developed theories of childhood development and education that lead to the evolution of constructivism. His ideas of Assimilation, Accommodation and Equilibration are really helpful for the learner to construct new knowledge. Kelly (1955) goes according to the lines of Piagets’ concepts of Assimilation and Accommodation. Ausubel (1963) examined the relationship between the processes of meaningful learning learners’ existing cognitive development. His theory also implies that learning takes place through an interaction between new materials and relevant prior knowledge that exists within the learners’ cognitive structure. Vygotsky (1978) introduced a social aspect of learning into the constructivism. His idea of learning is a social one, through interaction with others one learns. He says that through others we become ourselves, and explains the main point, Zone of Proximal Development. Glasersfeld (1987) described constructivism as a theory of knowledge with roots in philosophy, psychology and cybernetics, he proposed Radical Constructivism, and said that knowledge is not a transferable commodity and communication not a conveyance. Bruner (1996) proposes that learning is an active, social process in which students constructs new ideas based on their current knowledge. Wheatly (1991), holds two main principles, one is knowledge

is not passively received, but it is actively built up by the cognizing subject. Other is function of cognition is adaptive and serves the organization of the experiential world not the discovery of ontological reality, thus we do not find truth but construct viable explanation of our experiences. Schank (2000) believed that the children learn by doing rather than memorization and testing. By reviewing all these theoretical backgrounds of constructivism, it is quite evident that, it is learner-centred approach, learning is active process and learning is both individually and socially constructed.

The researcher has reviewed various studies conducted on the area of constructivism. The researcher has reviewed the main objectives, methodologies, tools and techniques used their findings and applications and drawn the implications for the present study.

The studies in reviews are focused on the effectiveness of Constructivist approach in science on students for increasing the academic achievement, developing science process skills, self efficacy, intrinsic value and learning strategies in Algebra and Biology, classroom management strategies, to enhance students learning and critical thinking (McDavitt & David 1995; Dethlefs, 2002; Gerbo, 2004; Sridevi, 2008; Kim, 2009; Hung, 2009; Treadwell, 2010; Brooks & John, 2010), examined students' views and suggested that the entire educational system recognize and make use of children's' natural cognitive processes through system-wide experiential education. Developing thinking strategies among students (Beatrice & Hall, 2010). Identifying other Constructivist learning characteristics among students (Brown & Gennean, 2010), Developed Technology based Constructivist environment for students (Senapathy, 2004), developing a program on creating a constructivist-learning environment using ICT to teach concepts skills in classroom management (Lourdusamy et al., 2001). Studies have been conducted on Pre-Service Teachers, to know their attitudes towards teaching and learning science, understanding of constructivist theory, (Gibson, 2000; Kroll, 2004; Forbes, 2009). And studied the effectiveness of ICT supported Constructivist Learning Approach (Joblonski, 2009), impact of university based science methods on Pre-Service Teachers' beliefs and abilities to design inquiry based science instruction for diverse learners (Galting & Pfitzner, 2010), examining the Pre-Service Teachers' participation in Web-enhanced, Case-Based Activity in Constructivist approach (Kim, et al., 2011), Integration of Technology practices in Pre-Service Teacher Education (Anita & Jayachandran, 2009; Martha & Casa, 2006),

Developing technological pedagogical content knowledge for Pre-Service Teachers (Marjorie & Terpstra, 2009), Pre-Service Teacher's perceptions and their readiness to infuse their technology (Ann & Koch 2009), On College biology students, ICT supported Constructivist Learning Approach to provide an understanding of how the 5E instructional method combined with educational technology tools can be used in teaching undergraduate college level anatomy and physiology laboratory classes (Lord,1997; Gopal & Tamilselvi, 2009).

Studies have been conducted on science teacher's valuation and implementation of formative assessment strategies in elementary science classrooms, science teachers perceptions of implementing constructivist principles into instruction, Online Professional Development program in Constructivist environment (Jett, 2009; Sounders & Soundra, 2009; Ekaterina & Koubek, 2002; Lynn & Markham 2008), Jonghwi & Park (2009) designed a well-formed activity system for an ICT supported Constructivist learning environment. Barry & Dorit (2005) validated and studied the effectiveness of an Online Questionnaire for Evaluating Students' and Teachers' Perceptions of Constructivist Multimedia Learning Environments. Ng'ambi & Johnsyon (2009) conducted a study on ICT mediated constructivist study for the academic support for teachers.

5.4 Implications for the Present Study

The result of the reviewing the related literature made clear that many studies followed the experimental design, where in the researchers purposed to see the effectiveness of designed, developed and implemented strategies on students and Pre-Service Teachers. Most of them have used Constructivist, Experiential Techniques. Hands-on experiments in small groups, Field Visits, Scaffolding Techniques, providing Multimedia environments, discussion through 5E Method, Argumentation Techniques, Classroom Interactions and Discussions. Followed self-assessment strategies. In the studies reviewed the investigators have used both Qualitative and Quantitative data collection tools, namely, Achievement test in science, Science Process Skills Test, Scientific Attitude Scale, Reactions Scale, Interview, Semi Structured Interviews, Narrations and Classroom Observations constructed by the researchers and dialogue journals, videotaped sessions and the instructor's reflective teaching journal used as data sources. This has matched with the researcher interest and motivated the

researcher to develop the program on ICT Aided Constructivist Learning Approach, and to go for experimental design and to develop various tools for the data collection namely, Achievement Test, Questionnaires, Reaction Scale, Interview and Semi Structured Interview.

Important findings and implications of the reviews include that, Experiential learning in science produced higher achievement at all levels of thought for learners of all ability levels (McDavitt & David S, 1995), the Constructivist teaching methods improved Pre-Service Teachers' perceptions about teaching science (Gibson, 2000), The constructivist leadership roles viewed as critical to impacting student achievement by High School Principals (Howard & Sester, 2004), it has helped Pre-Service Teachers to investigate their own ideas of learning and teaching with constructivist theory in order to think critically about their own practice in an ongoing developmental manner (Kroll, 2004), the constructivist approach found effective in science & implied that Constructivist approach is more effective than the Conventional method of teaching in science (Sridevi, 2008), Active Learning strategies in a large class were useful to enhance students' learning and to enhance critical thinking and engaging in critical thinking process. Collaborative activities such as working in team is the most important element contributing to students' learning; indicating that collaborative learning is a critical instructional element (Williamson & William 2010), through this approach pre-service teachers were able to translate their espoused inquiry framework into planned and enacted science lessons and have implications for practice and theory and provided novel insights into the teacher-curriculum relationship, teacher learning, the nature of goals of inquiry oriented science teaching-learning (Forbes, 2009), the students took advantage of the technology provided (Gopal & Tamilselvi 2009), the teacher educators need to call explicit attention to educational technology modeling and aid their pre-service teachers in making connection to possible and in conceptualizing technology can be used as a tool and employ lesson designing from the technology entry points (Marjorie & Terpstra, 2009). Lourdusamy, et al., (2001), suggest that Time management seems to be a factor that needs attention to help students cope with the one year program. This exploratory attempt to blend electronic media learning with face to face learning suggests that this mode of course delivery can be successfully used in teacher education by creating an interesting mix of learning activities and providing the incentives to the student teachers.

ICT aided Constructivism provides the platform for teachers and learners to develop their cognition regarding the concepts in general and science concepts in particular, appropriate use of technologies can make learning for students interesting and enriching. Therefore it is important that educators make serious considerations of matching the appropriate use of the technology with the content to maximize the students' potential in learning. Frand (2000) envisages that the educators' role of teaching the students may change with the introduction of technology. The phrase "sage on the stage" may change to "guide on the side" as educators take a step ahead from the normal role of being information giver to one, that the facilitator who creates the learning environment for the process of learning.

A disconnect has been found that the studies are either completely on School Education, or on Teacher Education, The link between teacher education and school education is missing. So there is dire need that researches should be done in teacher education and whose implications could be seen at school level, which may bridge the gap found. And the process of integration of ICT aided Constructivism should evolve from the teacher education programmes itself. If the revolution is expected in schools, it should starts from the Colleges of Education. In spite of different review have been highlighted and different areas both in school education and teacher education, more research could be in teacher education professional preparation and professional development areas through training and orientation programs. And research also could be done in trying the connecting theory in teacher education and practice in school education. All these ideas have contributed for the genesis of the present study.

5.5 Rationale for the Present Study

The infusion of Information and Communication Technology in education has created a significant impact on the instructional content development and the methods of communicating information to the learners. This leads to the evolution of new concepts and innovative teaching techniques in the teaching-learning process. It seeks to create a generation of learners whose learning is defined as the ability to retain, synthesize and apply conceptually complex information in meaningful ways (Lamberts & McCombs, 1998). It also encourages better student learning through the learning objectives of project based learning or learning by doing (Berman, et al., 1999) and to enable problem solving, analysis, creativity and communication to take place in the

classroom (Bates, 2000). ICT has been found to affect the student's motivation (Guthrie et.al.,2004) and it has also been found that using ICT in the Education helps to increase the interest in the subjects and understanding various levels of subject domains, increases critical and creative thinking (Maor,1999). With the help of ICT we can get access to information within a few seconds by internet and communicate the same to any person at any corner of the world. So in today's competitive world it is highly desirable that our students should not lag behind in terms of knowledge. ICT can transform the learning environment into one that is learner centered. It encourages active and collaborative learning. Only ICT implementation into education cannot do miracles, it should be integrated with certain learning theories.

Constructive Learning approach is basically student centered learning. It will give new status to the learner as the active constructor of the information within the learning activity instead of being passive respondent to the externally determined world of education. Constructivism challenges the learners to move beyond fact learning to more transferable cognitive understanding. From this approach Students can learn better and explore themselves, can get the self-awareness and meta-cognition. But in the present classrooms the teaching is going on in the traditional method where the students learn mechanically. Particularly, the subjects like Science where experiments are conducted, if the teaching is done in mechanical way, and then the students cannot go into the depth of the subject. They will lack both the scientific inquiry and scientific attitude. Studies have shown that when the classroom has the Constructivist Philosophy, the students gain the meaning out of the learning. With its help abstract concepts are becoming easy and concrete; the learning process is joyful. So, there is a need to adopt the constructivist learning approach. When various forms of information and communication technologies are used as tools in the constructivist approach it will create curiosity and interest among students.

Through only one or two strategies of the constructivist approach there was reported no change across traditional method; it requires a blend of mixed activities and approaches. There is gap found between teacher education instruction and practical school instruction that is theory and practice found to be disconnected. Time management is again the intervening factor in the teacher education colleges, there is a need for orientation courses on ICT aided Constructivist Learning Approach in Science thoroughly; it should be part of curriculum. School students are also in great

confusion in following different methodologies of their teachers and Pre-Service Teachers in the practice teaching , However entire educational system recognizes and makes use of children's natural cognitive processes through system-wide experiential education. Definition of constructivist practice and implementation of constructivist roles needs further research at all schools across the country. "In order for any discipline to survive, it must accommodate changes in theory and practice and do so in a way that adds value to the discipline" (Kuhn, 1972).

It is not easy to adopt this approach directly, for this teacher has to be prepared enough. In the constructivist classroom the responsibility of the teachers will be more. Teachers should be well versed in the knowledge and principles of constructivist approach. Here the knowledge is actively built, so teachers should provide the suitable learning environment like engaging students in learning, and encourage group interactions. Teachers should nurture students' natural curiosity through frequent use of ICT and provide the knowledge of ICT in various forms. The technology integration is a complex process and the ability to use it effectively for teachers, so professional orientations may help in this regard (Bandyopadhyay, 2013). Kimetal (2011) there is need of research to refine our understanding of situated case-based approaches' potential to promote both meaningful technology integration knowledge and skill and to address a range of everyday classroom teaching and learning issues, decisions, and practices. So, to achieve all these teachers must know the Constructivist approach and ICT in order to teach to their students. Therefore teachers have to be trained well before; they need professional development programs regarding ICT and Constructivist approach. It needs a paradigm shift and willing abandonment of familiar perspectives and practices and the absorption of new ones (Brookes, 1993). Teachers who are not familiar with the constructivist approach using ICT as tools may first require a change in the educational philosophy (Healy,1998). In the teacher education colleges, when Pre-Service Teachers enter their initial practicum experience they are confronted with differing teaching philosophies of their own, their professors and their school mentors (Sullivan et. al 2000). Within this situation, Pre-Service Teachers struggle to find their own niche of teaching science and learn to reflect as both learner and teacher (Kelly, 2000). Pedersen & Liu (2003) suggested that there is a need for professional development opportunities for teachers prior to their use of computer-

based programs designed to support student centered learning. Progress of this approach requires that Pre-Service Teachers be weaned off traditional approaches and they should adopt constructivist views of knowledge. In this regard the study by Boone & Kent (2009) found that it is important to bring change in education because it makes a contribution to closing the gap between theory and practice in the classroom.

If school teachers are expected to bring about a revolution in their approach to teaching, that, the same revolution must precede and find a place in the Colleges of Education. University Education Commission (1948-49) report stated that “People in this country have been slow to recognize that Education is a profession for which intensive preparation is necessary as it is any other profession” this report is alive in its relevance today (Siddiqui, 2009).

In the Indian context very few studies have been found which concentrated on designing constructivist learning approach for school students, and developing technology supported constructivist learning approach. Not many studies have been conducted on constructivism in India, and among all the studies reviewed, no such studies have been found which focus on professional development of teachers with technology integrated constructivist approach and whose effectiveness has been studied at the school level. But still an optimistic view could be drawn, there is positive inclination that NCF (2005) highlighted on Learning and knowledge in terms of constructivist pedagogy. Reorienting the curriculum to this end must be the highest priority. NCERT (2005) has highlighted the importance of constructivist perspective. This also created a base for conducting such studies.

There is a need to equip teachers with competencies to use ICT for their own professional development (NCF, 2009). To achieve this there is an urgent need of introducing ICT Aided Constructivist Learning Environment for the professional development of Pre-Service Teachers. So in the present study the importance of teacher’s preparation and support for the successful implementation of Constructivist approach using ICT as tools for the teaching is emphasized. Hence the present study has emerged.

5.6 Present Study

Development and Implementation of ICT Aided Constructivist Learning Approach for the Professional Development of Pre-Service Teachers

5.7 Objectives of the Study

1. To develop ICT Aided Constructivist Learning Approach in Science for the Pre-Service Teachers.
2. To study the effectiveness of ICT Aided Constructivist learning Approach in Science in terms of
 - i. Reactions of Pre-Service Teachers.
 - ii. Reactions of School Students.
 - iii. Reactions of Teacher Educators.
 - iv. Academic achievement of School Students.
 - v. Observations by the Investigator, Pre-Service Teachers and Teacher Educators.
 - vi. Reflections of Pre-Service teachers.
 - vii. The emerging status of the ICTACLA
3. To study the level of professional development of Pre-Service teachers through ICT Aided Constructivist Learning Approach.

5.8 Hypotheses

1. There will be no significant difference between observed frequencies and expected frequencies against equal probability on various statements of Reaction Scale for Pre-Service Teachers
2. There will be no significant difference between observed frequencies and expected frequencies against equal probability on various statements of Reaction Scale for School Students.
3. There will be no significant difference between pre-test mean and post –test mean scores from single of the School Students.
4. There will be no significant difference between the observed frequencies and frequencies expected against equal probability on various elements of Observation Schedule.

5. There will be no significant difference in the observations of practice teaching lessons by the Researchers, Pre-Service Teachers and Teacher Educators.
6. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Experimental group of Pre-Service Teachers As Learners.
7. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Experimental group of Pre-Service Teachers As Teachers.
8. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Experimental group of Pre-Service Teachers both As Learners and As Teachers.
9. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Control group of Pre-Service Teachers As Learners.
10. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Control group of Pre-Service Teachers As Teachers.
11. There will be no significant difference in the Pre-Intervention observed frequency distribution and Post-Intervention observed frequency distribution against the Five class Intervals for Control group of Pre-Service Teachers both As Learners and As Teachers.
12. There will be no significant difference in the Pre-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers As Learners.
13. There will be no significant difference in the Pre-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers As Teachers.
14. There will be no significant difference in the Pre-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers both As Learners and Teachers.
15. There will be no significant difference in the Post-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers As Learners.

16. There will be no significant difference in the Post-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers As Teachers.
17. There will be no significant difference in the Post-Intervention observed frequency distribution against the Five class Intervals for Experimental and Control group of Pre-Service Teachers both As Learners and Teachers.

5.9 Operational Definition of the terms

5.9.1 Information and Communication Technology

Information and Communication Technologies in the present study includes MS Office, Internet Surfing, Creation and Sharing of Blogs, Wiki-Space, Wiki-Education, Wikipedia, Social Network Services, Hyper Linking, Navigating, Use of Educational Softwares. And use of all these for the process of Development and Implementation of the Intervention Programme.

5.9.2 ICT Aided Constructivist Learning Approach

ICT Aided Constructivist Learning Approach in the present study refers to the Programme developed by the Researcher by using Constructivist Learning Principles with the help of ICT. The Programme is inclusive of concepts of ICT, Constructivism, and Integration of ICT Aided Constructivist learning approach for the professional development of Pre-Service Teachers and model Science Lesson designs employing ICTACLA.

5.9.3 Professional Development of Pre-Service Teachers

The Professional Development of Pre-Service Teachers in the present study includes the development of knowledge, understanding, skills and applications on ICT Aided Constructivist Learning Environment at College of Education level and School level. It has been studied through orientation programme; Designing and practicing the lessons employed ICTACLA at the college level and implementing them at the school level by the Pre-Service Teachers, Questionnaires, Reaction of School Students, Pre-Service Teachers and Teacher Educators, Achievement of School Students, through observations, Focused Group Discussions and Semi-Structured Interview.

5.10 Delimitations of the Study

The study was delimited to Science Pre-Service Teachers of Secondary level.

5.11 Design of the Study

Experimental Design

For the Pre-Service Teachers Experimental Control group Pre-Test and Post-Test Quasi-Experimental Design has been employed, whereas, for Schools Students Single group Pre-Test Post-Test Pre-Experimental Design has been employed.

5.12 Population for the Study

In the present study, the population is constituted of all the Science Method Secondary Pre-Service Teachers of Karnataka State (2011-2012), and all the Secondary School Students of IX Std. of Karnataka State (2011-2012).

5.13 Sample for the Study

1. Sample includes all the 35 Science Method Pre-Service Teachers of University College of Education Dharwad, as the Experimental Group, whereas, that of 30 Science Method Pre-Service Teachers of Dr. Kamala Baliga College of Education, Kumta, as the Control Group of the academic year 2011-2012.
2. All the IX Std. students of two practicing divisions from each school of all six practicing schools of University College of Education were considered as student sample. About 437 school students constituted the sample.
3. The Colleges of Education were selected purposively, whereas, the Pre-Service Teachers and the School Students were selected through cluster sampling.

5.14 Tools and Techniques

The Tools, namely Questionnaire, Reaction Scales, Observation Schedule, Semi-Structured Interview Schedule were constructed by the Researcher and validated by the Experts. Reliability of the Questionnaire was found through Test-Retest method. Achievement Tests were constructed by the Pre-Service Teachers. Field Notes were taken by the Researcher. Pre-Service Teachers' Observed Daily Diary and Conducted Focused Group Discussion with the Pre-Service Teachers. Rubrics has been constructed to assess the lesson designs.

5.14.1 Questionnaire

The Researcher constructed a Questionnaire by following the general principles and characteristics of Constructivist Learning Approach and Integration of ICT and The development of questionnaire followed the five point Likert Scale - Very Often, Often, Sometimes, Seldom and Never. The questionnaire contains the two forms, namely, As Teachers perceived form and As Learner perceived form. As Teacher perceived form contains 54 items which include 47 positive and 7 negative items and As learner perceived form contains 86 items which also contain 74 positive and 11 negative items. The questionnaire was used to collect the data related to the Pre and Post intervention professional status of Pre-Service Teachers. The content validity was established by the experts and the Researchers found the reliability by test and retest method.

5.14.2 Reaction Scales

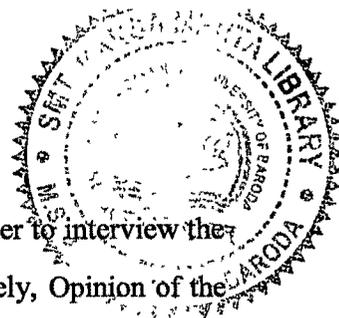
Reaction Scales were constructed by the Researcher to study the reactions of School Students, Pre-Service Teachers and Teacher Educators towards ICTACLA. Reaction Scale for School Students contains 27 items, for Pre-Service Teachers 42 items, whereas, as for Teacher Educators 16 items. All these are on 3 Point Scale - Always, Sometime and Never.

5.14.3 Observation Schedule

An Observation Schedule was constructed by the researcher to observe the implementation of lessons designed by Pre-Service Teachers through ICTACLA during practice teaching. The observation schedule contains the elements to be observed, namely like classroom environment, teacher behaviour, Learner participation and interaction behaviours in the practice teaching classes

5.14.4 Achievement Tests

The tests constructed by the Pre-Service Teachers to study the Academic Achievement of School Students, both, Pre and Post intervention in the practice teaching, wherein, they conducted the classes by employing ICTACLA.



5.14.5 Semi-Structured Interview Schedule

Semi-Structured Interview Schedule was developed by the Researcher to interview the Pre-Service Teachers on ICTACLA. It contained the aspects, namely, Opinion of the Pre-Service Teachers regarding ICT Aided Constructivist Learning Approach, Utility of ICTACLA in Science, Feeling during the preparation of the lessons employing of ICTACLA for Practice Teaching, Experiences during practice teaching using ICTACLA in the schools, Role of Pre-Service Teachers in the ICTACLA in future teaching Profession, Organization of Instructional Environment employing Constructivist Learning Approach, Problems faced during lesson preparation employing ICTACLA, Problems faced during practice teaching employing ICTACLA, Opinion regarding the effectiveness of ICTACLA and Suggestions on the orientation programme employing ICTACLA in Science.

5.14.6 Focused Group Discussions (FGD)

The Researcher has conducted Focused group discussion with Pre-Service Teachers to collect their reflections on ICTACLA. In the present study the Focused Group Discussion gives the insight of the process of ICTACLA in terms of their reflections. The initial reflections of the Pre-Service Teachers on ICTACLA have probed them to discuss various aspects further namely, feel of ICTACLA, ICTACLA facilitating Science, lesson designing employing ICTACLA, experiences during practice teaching while employing ICTACLA, exploring the Possible Role of Pre-Service Teachers in the context of ICTACLA in their Profession, Designing Constructivist Learning Approach Environment, problems faced during Practice Teaching with ICTACLA, Effectiveness of ICTACLA in Science, Suggestions of the Pre-Service Teachers on ICTACLA in Science.

5.14.7 Pre-Service Teacher's Diary

The Researcher has provided each Pre-Service Teacher a note-book to mention the daily activities on ICACLA throughout the programme, their views on the orientation programme and suggestions for further improvement. These diaries were collected by the researcher at the end of the orientation programme.

5.14.8 Researcher's Diary for Field Notes

The Researcher maintained the diary from the first day to the last day of data collection, wherein the notes were taken during orientation in the College of Education, during practice teaching and after practice teaching.

5.14.9 Rubric

Rubric was constructed and used by the Researcher to assess the lesson plans of Pre-Service Teachers which are designed based on the ICTACLA. The constructed Rubric contains 12 Categories, namely, Learning Objectives, Required Elements, Cooperation, Use of ICT, Use of Students Prior Knowledge, Use of Students' Interest, Use of student-centered activities, Engagement, Exploration, Explanation, Elaboration and Evaluation. The lessons were assessed on 4 point scale namely, Excellent, Very Good, Satisfactory and Needs Improvement.

5.15 Development of the Program on Information and Communication Technology Aided Constructivist Learning Approach (ICTACLA)

The researcher has developed a Program for orientation of the Pre-Service Teachers on ICTACLA. Developments of the Program in terms of Introductory Manual where in various modules have designed and developed are:

I. Information and Communication Technology (ICT)

- Introduction
- ICT and Education
- Integration of ICT in Education
- Model of ICT Integration
- Role of ICT in Instruction
- Web 2.0 technologies
- Activities

II. Constructivist Learning Approach

- Introduction
- History
- Concept
- Types
- Principles

- Constructivism and Learning Process
- Constructivism and Teacher
- Constructivism and Learner
- Pedagogy based Constructivism
- Constructivist Learning Designs
- Activities

III. ICT Aided Constructivist Learning Approach

- Introduction
- Model Lesson Plans of ICT Aided Constructivist Learning Approach.
Designed and Developed ICTACLA based Lessons on various Science concepts by using various Constructivist models, namely, 5E's and 7E's and Constructive Learning Cycle Model, The Information Construction (ICON) Model and Inquiry Based Model.

The Introductory module has been developed and its content validated by experts in the field. This has been used as a resource by the researcher during the orientation programme delivered to Science Pre-Service Teachers.

5.16 Collection of the Data

The data were collected through the following phases:

Phase 1

In the first phase the researcher studied the entry professional level of Science Pre-Service Teachers on ICTACLA through the Questionnaire. The researcher conducted the same test on the control group, but the control group was not orientated on ICTACLA.

Phase 2

The Researcher oriented all the Pre-Service Teachers towards ICT and basics of ICT skills by providing examples, activities and discussions. The concept of Constructivism was made clear through activities, demonstrations and discussions and followed by group activities and presentations. The Researcher oriented the Pre-Service Teachers on the ICT Aided Constructivist Learning Approach in Science. Here in this phase the researcher demonstrated the Model Lesson Plans from the Introductory Manual. The researcher created the Constructivist Environment in the

guidance classes, wherein the researcher started the orientation by following ICTACLA, made groups among the Pre-Service Teachers, provided group activities as per the themes and followed by group discussions and feedback. Conducted field trips both on-campus and off-campus. Researcher along with the Teacher Educators has taken Pre-Service Teachers to University of Agricultural Sciences Dharwad. Where in they visited green houses, various fruits farms, Dairy, Poultry, Horticulture Department, and Department of Home Science, Agricultural Research Centre and many other departments. In the field visit Pre-Service Teachers have been given lectures by the Agricultural Scientists, Professors and conducted brain storming sessions. Researcher also suggested Pre-Service Teachers to include field visits in their classes in schools.

Phase 3

Lesson plans were designed by the Pre-Service Teachers by employing ICTACLA. These were corrected by the researcher; Pre-Service Teachers presented and practiced the lessons in class and collected feedback. This process was continuously going on till they got acquainted with the ICTACLA. Also the researcher oriented them on the observation of lessons conducted through ICT Aided Constructivist Approach during the practice teaching.

Phase 4

Pre-Service Teachers designed the lessons through the ICT Aided Constructivist Approach as per the orientation for the Practice Teaching by the researcher. Along with designing the lesson plans, Pre-Service Teachers developed their own different teaching aids; they referred various online resources for developing the teaching models and teaching aids.

Phase 5

Pre-Service Teachers conducted Pre-Test for school students and implemented the lessons with ICT Aided Constructivist Approach in their practice teaching. Here Pre-Service Teachers conducted the classes by creating constructivist environment, where in the classes were active and lively, made groups among the students during discussion, performed experiments with the help of students, taken all students to the campus gardens and ponds. Engaged all the students towards classroom activities. In the classroom some of the Pre-Service Teachers showed the virtual field trips to

students on various concepts. The Teacher Educators observed the implementation of lessons. The other Science Pre-Service Teachers who were attending the particular class also observed the lesson. The researcher also observed the implementation of the lessons as a participant observer and noted the important points of the implementation process and classroom activities. Photos and Videos of experiments and some discussions were taken. Pre-Service Teachers conducted Post-Test in terms of achievement test at the end of the lessons.

Phase 6

The Researcher collected the Reactions of School Students towards the ICTACLA. In each of the school the Researcher collected reactions from the students of those classes where Pre-Service Teachers conducted the classes based on ICTACLA.

Phase 7

The Researcher studied the Effectiveness of these lessons through Academic Achievement of school students in the Post-Test conducted by Pre-Service Teachers.

Phase 8

The Orientation was continued after practice teaching because Pre-Service Teachers needed to deliver innovative lessons which were one month after practice teaching. All the Science Pre-Service Teachers liked to deliver their lessons on ICTACLA. So they demanded some more discussion on this. Accordingly they practiced some more lessons employing ICTACLA and presented their lessons. The researcher observed and noted all the practices as a participant observer.

Phase 9

Researcher Collected the Reactions of Pre-Service Teachers and Teacher Educators towards ICTACLA by administering the Reaction Scales. Conducted written Semi-Structured Interview about the orientation programme on ICTACLA in terms of specific aspects. Conducted the Focus Group Discussion with the Pre-Service Teachers regarding the orientation programme on ICTACLA which was video recorded. Post-Test was administered on ICTACLA to study the at end level of Pre-Service Teachers on ICTACLA.

The researcher conducted the Post-Test on the Control group also.

5.17 Data Analysis Techniques Employed

The collected data were analyzed both qualitatively and quantitatively. Responses on the Questionnaires were analyzed through Chi Square Contingency; Responses on the Reaction scales were analyzed through Chi Square. Observations were analyzed through frequency percentage count, Chi Square and Academic Achievement analyzed through Mean, SD and 't test'. Semi-Structured Interview and Focused Group Discussions, Pre-Service Teachers' Diary and the Researchers' Field notes were Content Analyzed. Lesson designs were analyzed by Rubric through frequency and percentage. Objective wise, tool wise the data analysis techniques have presented in the Table 31.

Table 31. Objectives and Tools wise Analysis of the Collected Data

Objectives	Tools / Programme	Analysis Techniques Employed
1	ICTACLA	Designed, Developed and Validated.
2.1, 2.2 & 2.3	Reaction scales	Chi Square & Frequency, Percentage Count
2.4	Achievement test	Mean, S.D. and t- test
2.5	Observation	Frequency & Percentage count & Chi Square
2.6	Semi-Structured Interview	Content Analysis
2.6	Focused Group Discussion	Content Analysis
2.7	Pre-Service Teacher's Diary & Researcher's Diary	Content Analysis
3	Questionnaire	Chi Square Contingency

5.18 Findings of the Study

Based on the analysis of the collected data, the following findings were obtained. The findings are presented objective wise as follows:

5.18.1 Finding of the Objective no.1

- ICT Aided Constructivist Learning Approach (ICTACLA) inclusive of Lesson Designs through ICTACLA and Introductory User Manual was found to be well developed.

5.18.2 Findings of Objective no. 2

- ❑ The Pre-Service Teachers, School Students and Teacher Educators were found to have favourable reactions towards the developed programme based on ICTACLA.
- ❑ There has been found significant difference between the Post-Test mean and Pre-Test mean scores of single group Pre-Test and Post-test of the School Students. So the classes conducted through ICTACLA in schools by Pre-Service Teachers have found to be effective. So the Intervention provided to the Pre-Service Teachers has been found to be effective.
- ❑ A large majority of the Pre-Service Teachers has very often and often manifested ICT Aided Constructivist behaviours in the Practice Teaching classes, as observed by the Researcher, The Science Pre-Service Teachers and Teacher Educators.
- ❑ There has been found be no significant difference in the observations of practice teaching lessons by the Researchers, Pre-Service Teachers and Teacher Educators. Hence the observations made by all the three are in tune with each other.
- ❑ ICTACLA in Science has been found to be innovative through which the teaching-learning in Science has become meaningful and ICTACLA has been found to be very effective in Science Teaching & Learning, as evident through the Interview by the Researcher with the Pre-Service Teachers.
- ❑ Through Researchers' Field Notes it has been found that the Pre-Service Teachers' got acquainted with the ICTACLA progressively, and found it to be an effective approach.
- ❑ The Pre-Service Teachers experienced a new and efficient way of teaching-learning as evident through Pre-Service Teachers' Diaries.

5.18.3 Findings of Objective no. 3

- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group of Pre-Service Teachers as Learners Pre-Intervention and Post-Intervention.
- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group of Pre-Service Teachers as Teachers Pre-Intervention and Post-Intervention.

- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group of Pre-Service Teachers both As Learners and As Teachers Pre - Intervention and Post - Intervention.
- ❑ The frequencies at the Post-Intervention level of the Experimental group are on the higher points of the scale namely Very Good and Good have been found to be greater than those at the Pre-Intervention level of Experimental group. So, the Intervention has been found to be effective.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Control group of Pre-Service Teachers As Learners Pre-Intervention and Post Intervention.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Control group of Pre-Service Teachers As Teachers Pre-Intervention and Post Intervention.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Control group of Pre-Service Teachers both As Learners and As Teachers Pre-Intervention and Post Intervention.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers As Learners Pre-Intervention.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers As Teachers Pre-Intervention.
- ❑ There has been found no significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers both As Learners and As Teachers Pre-Intervention.
- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers As Learners Post-Intervention.
- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers As Teachers Post-Intervention.
- ❑ There has been found a significant difference between the observed frequencies on perceptions of Experimental group and Control group of Pre-Service Teachers both As Learners and As Teachers Post-Intervention.

- ❑ Hence both the groups at the Post- Intervention level differed significantly; the significance is attributed to ICTACLA.
- ❑ It is evident from all the findings that the ICTACLA has been found to be effective at both the Teacher Education and School level.
- ❑ It is evident through all the findings that the ICTACLA has been found to be effective in facilitating the Professional Development of the Pre-Service Teachers.

5.19 Study Based Reflections

The present study provides the insight about the process of how ICTACLA facilitates meaningful learning, in turn how it contributes for the professional development of the Pre-Service Teachers. In India there is big concern of quality teachers for maintaining quality education. The quality teachers can be developed only through quality teacher education programmes. The present piece of research has proved that by integrating innovative teaching-learning methods particularly ICTACLA, the Pre-Service Teachers have transformed into teaching scientists by adopting Constructivist philosophy in the class and integrating ICT in the activities. The Pre-Service Teachers found the ICTACLA a very effective way for teaching-learning of Science. The following are the reflections emerged based on the study,

- ❑ The present study provides an insight into the meaningful learning of Science through ICTACLA.
- ❑ The present study showcases the importance of learner-centred approach to teaching-learning.
- ❑ The present study builds the strong foundation for putting theory into practice.
- ❑ The present study highlights the role and responsibilities of learner, teacher, and administrators and policy makers.
- ❑ The present study also helped the both Pre-Service Teachers and School Students to develop critical and creative thinking skills, communication skills, problem-solving skills and leadership skills.
- ❑ The present study viewed learners as discoverers and constructors of knowledge. Hence all learners are taken as perspective of learner scientist.
- ❑ The program on ICTACLA developed interest and sustained curiosity among the learners throughout the course.
- ❑ ICTACLA looks at the wholistic development of learners.

- ICTACLA considers evaluation as both summative & formative and qualitative and quantitative.
- ICTACLA in Science has helped the School Students to score well in the academic achievement.
- Through ICTACLA both Pre-Service Teachers and School Students become netizens.
- Group work and group discussions help the learner to develop positive attitude towards Science.
- ICTACLA in Science engages the learners throughout the classroom.
- ICTACLA helps the learners to collaborate with the experts.
- ICTACLA helps to learn and integrate web 2.0 technologies.
- Individual consideration and respect for each individual idea is possible in ICTACLA.
- Actual and virtual Communication is made possible through ICTACLA.
- The idea of scaffolding works out to be better to learn unknown things.
- A real learning happens when the learners apply the classroom ideas to outer environments.
- Science as a subject can be considered as a process rather than a product.
- Motivation is very important factor for the meaningful learning.
- Through ICTACLA learners can think divergently.
- When freedom is given to learners, they come up with their own creative ideas and can express them through various modes.
- Learners can work out the things which are equal and little above to their levels with peer interaction and guidance of the teacher.
- First hand experiences through field visit and experiments are vital and play important role in the process of learning.
- Learning happens rapidly when the problems are related to the interest of students.
- Problem-solving skills develop through group learning.
- School, Teacher Education College and society must provide the creative soil for the new ideas and encouragement and hardihood to put those ideas into action.
- The Orientation on ICTACLA to Pre-Service Teachers really helps to bring the change in the process of teaching-learning.

5.20 Implications of the Study

- ❑ ICTACLA should be promoted as one of the essential teaching approach in the Schools and Colleges.
- ❑ Universities should take care of advancements in teaching-learning process while prescribing syllabus for Teacher Education Colleges. As Curriculum at the national level changes and considers advancements, Universities should also get updated accordingly.
- ❑ School Education should provide the congenial environment for both teachers and learners suitable for integrating ICTACLA.
- ❑ Teacher Education Colleges should possess all the facilities namely, Science Laboratory. Computer laboratory, Demonstration rooms and well trained laboratory assistants.
- ❑ The Administration in the schools should provide the facility of ICT to their students and also for the use of Pre-Service Teachers. The Smart class future ready schools also should provide the facility to Pre-Service Teachers during practice teaching.
- ❑ Both Colleges of Teacher Education and Schools should be inclusive of Science activities and field trips both on campus and off campus.
- ❑ Science should be viewed as a process rather than product.
- ❑ In Colleges of Teacher Education freedom should be given to Pre-Service Teachers to design their own lessons rather than sticking to university prescribed pattern.
- ❑ Colleges of Teacher Education should provide opportunities for Pre-Service Teachers to reflect on their own learning and teaching.
- ❑ Pre-Service Teachers should be trained to be Techno-savvy and Info-savvy.
- ❑ Teacher Educators should also be constructivists in the process of teaching.
- ❑ Pre-Service Teacher Education Programme should be Strengthened and Lengthened.
- ❑ Pre-Service as well as In-Service Science Teachers should get more orientations and workshops on ICTACLA from the experts.

- Teacher Educators and School Teachers should undertake Action Research on effectiveness on ICTACLA.
- Research and Development is needed in the area of Science Education based on ICTACLA at the National level.
- Presently Learning happens actually and virtually, So, Virtual learning and virtual learning communities should also be encouraged.
- Encouragement and motivation should be provided to all those who practice ICTACLA in schools and colleges.
- Both Summative and Formative Assessments should be given due importance.
- The Philosophy of Constructivism should be embedded in all the level of education.
- ICT can be integrated as a catalyst of learning.
- ICTACLA could be integrated in India in a Phased Manner.
- Rigorous orientations should be provided to the Pre-Service Teacher, In-Service Teachers and University Teachers on ICTACLA.

5.21 Suggestions for Further Research

Any piece of research conducted opens up new areas for further research. The present study on development and implementation of ICTACLA for Pre-Service Teachers has been found to be effective. It has created an avenue for more researches to be conducted in future, namely,

- ❑ Research could be conducted on Integration of ICTACLA at various levels of Teacher Education.
- ❑ Research could be conducted on Integration of ICTACLA at various levels of School Education.
- ❑ Research could be conducted on various subjects employing ICTACLA.
- ❑ Research could be done on various forms and models of ICTACLA, both in Teacher Education and School Education.
- ❑ Research could be conducted in Central Board of Secondary Education (CBSE), Other State Secondary Education Boards. Indian Certificate of Secondary Education (ICSE) schools and International General Certificate of Secondary Education (IGCSE) schools.
- ❑ The Developmental Research can be conducted to study how children construct knowledge at different levels.
- ❑ Research could be conducted to study the effectiveness of ICTACLA for Pre-Service Teachers in Distance mode.
- ❑ Research could be conducted on providing orientation to Teachers at College and University levels of different subjects.
- ❑ Research could be conducted to establish the co-relation between ICT and Constructivism.
- ❑ Research could be conducted on Connectionist Approach which is the extension of Constructivist Approach.

5.22 Conclusion

Every individual learner is a Scientist. New knowledge is constructed by scaffolding to earlier one by metacognising the abilities. In reality the understanding of the concepts is possible only when a learner attaches meaning to it and applies it to his own social environment. The philosophy of Constructivism offers the opportunities to engage, to explore the idea through germination, incubation, creation and construction of new knowledge. Any learner working with the constructivist ideas will certainly learn the concepts meaningfully. In the constructivist classrooms teacher never teaches to pupils, rather attempts to facilitate the conditions in which they feel ease to learn. As Science is a subject of experiencing through experiments, which needs the teachers and learners who are active agents to experiment integrating ICT into the constructivist learning environment for the meaningful learning of Science. Science is both a process and product, but the teaching of Science as a whole is largely product based. The Scientific process skills are wanting. It is expected that ICT to bridge the gap between process and product. As the present world is moving with rocket speed, the traditional chalk and talk methods will not suffice the needs of the present learners. So the teachers need to be updated in innovations in teaching-learning. First hand experiences provide the clear picture of the Science ideas, where learner cognises with senses. The teacher can arrange for the activities, experiments and demonstrations as much as possible in the class. They can take the support of ICT, which can be considered as catalysts of knowledge construction and offers a wide array of teaching-learning tools to use. By integrating ICT in constructivist classes teachers can provide plenty of opportunities to the learners to create and construct the knowledge. ICTACLA has been found to be effective for the professional development of the Pre-Service Teachers as evident both at Teacher Education College level and School level. It has transformed the Pre-Service Teachers into teaching Scientists and students to constructors of knowledge. The orientation on ICTACLA helped the Pre-Service Teachers not only to be aware of ICTACLA, but also made them creative and critical thinkers, problem-solvers and developed communication skills and leadership skills. They come to know about their abilities of learning when freedom in the Science

classes was given. When the Pre-Service Teacher's put ICTACLA into practice in schools, school students scored well in the achievement test. Group discussions made them to develop and foster positive attitude towards learning of Science. Implementation of ICTACLA and getting along with the ICTACLA for Pre-Service Teachers was challenging initially. But, it is evident that the motivation provided for integrating it in the classrooms during practice teaching has worked successfully. Educational instruction has not been in a position to keep pace with the advancement in ICT. The present study has very well demonstrated that despite the limited ICT accessibility in schools, how procuring ICT facilities on their own the Pre-Service Teachers have used it employing constructivist approach for Science teaching-learning. The interest, curiosity and dedication of the Pre-Service Teachers developed them into Techno-Constructivists. The Constructivist approach demands round the clock curiosity and sensitivity and its follow up into experimentation establishing cause and effect arriving at principles and inventions and constructions thereof. In nut shell, the study reveals that there is a need of construction and production along with consumption. Science as a discipline can remain alive only with progressive revelation and construction. The present Education system needs innovative models of professional development for both the Pre-Service and In-Service Teachers to keep them and their students updated in the changing world. The present piece of research is a sincere and humble effort to put the theory into practice.