CHAPTER II
REVIEW OF RELATED LITERATURE

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The review of literature i.e. articles, research papers, thesis, etc. aim to -

- Study the present status of the variable/phenomenon being studied
- Identify important ideas, theories, authors, findings in the area
- Identify gaps, if any, in research

Reviewing is a continuous process and helps in bringing clarity to the conceptual understanding of the area under research and investigation. It helps in answering of the research questions formulated for the area under research and if the research questions have been answered, then which questions need to be re formulated or changed. Review should not be limited to certain journals, time or methodology.

For the present review, articles from journals, books, thesis which were related to the topic were studied. The review for the topic was studied under following broad themes:

- **Integration of ICT**

  This theme gives a broad overview of use and integration of digital technology in the teaching and learning process, how it can be used, obstacles faced and other related issues. This section refers to conceptual papers, reports and surveys done related to use of ICT.

- **Researches related to development of Higher order thinking skills and related concepts**

  The purpose of this section is to collate all the information available about Higher order thinking skills, critical thinking or 21st century skills- their theoretical underpinnings, ways to inculcate them as well as their assessment. The terms higher order thinking skills, critical thinking have been either used in literature interchangeably or have similar scope/dimensions. Theoretically the basis of the terms and their nuances are beyond the scope of this review, hence, the references consist of conceptual papers which is similar to the operational definition of 'higher order thinking skills' as used in the present

study. Papers describing initiatives for teaching HOTS have also been reviewed in this section.

- **Factors influencing use of ICT by teachers and students**

  This theme outlines the factors which predict better usage of technology available in the teaching and learning process by the teachers and students, and also the barriers to technology usage. It also discusses predictors for successful implementation of ICT in the teaching and learning process.

- **Effect of ICT on Higher order thinking skills**

  The scope of this theme is to review the literature available depicting relationship between use of ICT (in different tools/forms) and development or improvement of HOTS in students through teaching and learning process.

INTEGRATION OF ICT

McCormick and Scrimshaw (2001) stressed on the point of revamping the pedagogy across subjects to for successful implementation of ICT in the teaching and learning process. The three approaches of ICT utilization in pedagogy have been broadly defined in 3 approaches according to the authors of the paper:

- 'ICT as an efficiency tool'

This approach deals with delivering the content with an electronic means i.e. computer, Smart board , with the other dimensions of the teaching and learning process remaining largely unchanged.

- 'ICT as an extension device'

In this approach Internet plays an important role. Using Internet, can enhance and enrich the student's experience; teachers may suggest certain websites for reference in different subjects, help students connect with real life scientists or historians or even students and teachers from other places or alternatively, students search for content on their own and decide on the genuineness of the plethora of information given online. This approach sees slight transformation in roles of teachers and students in the classroom.

- ‘ICT as transformative device’

Using this approach the roles of teachers may change, drastically. Often outside sources like websites, media available may replace teacher. The goal is not mere acquisition of knowledge but its creation. Students may often face difficulty in judging if the source of knowledge is valid or not. The experiences of learning change, authors give an example of an assignment in art wherein it is completed using technological tools rather than paint and brush. It also, brings forth certain problems of manipulation of others work and assessment can also become difficult.

Authors presented their views on the above mentioned approaches through a table, covering different ‘dimensions of pedagogy’:

- Purpose and goal of each approach
- Learning according to each approach and through view of ‘radical constructivist’, ‘cognitive constructivist’ and ‘social dimension’
- Views on knowledge
- Activities for learning and assessment
- Roles of teachers and students and their relationships
- ‘Discourse’

The implication presented in the paper give important considerations for developing curriculum with ICT. Since, the authors are from United Kingdom they give a glimpse of conditions prevailing there. They discuss a gap in pre-service training as well as in service training of teachers wherein there is no clear perception of teachers on understanding the concepts of ‘teaching and learning’ process; which in turn will help teachers to adjust better with their changing roles in respect to increased use of ICT in classrooms.

Pelgrum (2001) in his paper brought forth the results of Second Information Technology in Education Study (SITES) carried by International Association for Evaluation of Educational Achievement (IEA) in 1997, for discussion. The study was divided in 3 phases- Module I, II and III. The paper discusses the results obtained from Module I carried out in 1997-1999, with its focus on schools from 26 countries. The aim is to highlight the obstacles to ‘realization of ICT- related goals of schools’ especially in the context of elementary and lower secondary schools.

Countries across the world are developing or have policies in place to integrate ICT in the teaching-learning process in schools. Surveys like SITES help in monitoring of these policies and their implementation and also, help in charting further direction of these policies and comparison with other countries.

The present information society demands an educational system which places students as an 'active learner', new pedagogy is required to help them to be independent. However, being an 'active' and 'independent' learner is an assumption of the fact that the learner has access to all knowledge. The teachers need to help and guide students and effectively communicate with them. Also, it is imperative to help teachers use innovation in their teaching-learning process and role of teachers is guided by the stand of the management. Thus, one can realize the importance of different factors playing role in integration and implementation of ICT.

SITES Module I broadly discusses the information collected from schools under 5 broad guidelines:

(1) Curriculum
(2) Infrastructure
(3) Staff development
(4) Management and Organisation
(5) Innovative practices

The results show that secondary schools have more computers than primary schools which have a higher percentage of multimedia computers (Part of infrastructure guideline). In terms of curriculum- countries vary largely on basis of 'Student controlled learning', their ICT skills and usage of Internet especially at the primary education level. In the lower secondary educational level, the data depicts importance of student controlled learning, ICT skills and Internet usage which requires in depth observation to draw conclusions. Since, it cannot be concluded whether the schools scoring higher on this scale have changed the pedagogy or the countries in the survey represent the most innovative ones.

It was also found that training teachers in ICT is a goal for all participating countries, however, this goal is realized in few. The data obtained was further analyzed to come

up with a list of obstacles faced in ICT implementation in countries. The top obstacles are:

(1) Insufficient number of computers
(2) Insufficient peripherals
(3) Shortage of software copies
(4) Less number of computers with access to internet
(5) Lack of ICT skills of teachers
(6) Specific scheduling of time for computer usage
(7) Teacher's lacking time to practice ICT
(8) Teachers not up to date
(9) Lack of supervision/ technical staff

The author also analyses the 'contextual factors' for the obstacles- insufficient amount of computers, lack of knowledge and skill of teachers and limited access to internet on computers.

What can be observed from the data obtained is that even with computer-student ratio less than 10, the respondents have given 'lack of computers' as an obstacle which may indicate that either effective usage of hardware lacks or there is actual shortage of (working) hardware. Acquisition of computers, knowledge/skill level of teachers can be a reflection of ICT policies adopted by school. A correlation was observed with the presence of ICT support/technician/ staff in schools and lack of complaints by school principals regarding lack of ICT competency of their staff indicating that ICT support staff is helpful for the school teachers.

Hew and Brush (2007) tried to find gaps in literature available for integration of technology at school level. They identified 123 barriers which were divided in six broad categories – resources, institutional, skills, attitude and belief, assessment and culture of subject. The most commonly reported barriers were in the following order: resources, skills, institutional, attitude and beliefs, assessment and subject-culture, respectively.

The resources as a barrier included: lack of infrastructure, access and support to use of technology. No technological support available while using ICT tools was also identified as a barrier. Teachers were also often short of time as preparing lessons

with integrated technology encompassed a number of tasks and subsequently, time. For integration, lack of specific skills or pedagogy of technological usage in lessons were also identified as barriers. When teachers have basic knowledge of integrating technology in their lessons, it is easier for them to plan lessons and utilize ICT tools in their teaching process. Many teachers often focus just on using technology, hence lack the knowledge of integrating ICT. The authors also mentioned that the teachers beliefs shape their attitude to use technology. Role of school principals was also found to be important as when they support technology use, they promote usage of technology by teachers.

At school level, time table and planning for usage of ICT tools were found to be important factors for technology integration in the teaching-learning process. However, there was a lot of emphasis on the final learning outcomes, it was found that usage of technology was restricted as there was pressure on teachers to complete the course on time. The authors found gap in research and mentioned that more in-depth studies needed to be conducted to assess the importance of time-table and subject-culture in purview of integration of technology in the teaching-learning process. Since different subjects have different content, its assessment and pedagogy, they are influenced by different factors.

The authors also proposed a model identifying relationship among different barriers and showed that integration of technology is directly influenced by teachers' attitude and belief, their knowledge and skills, school level factors and availability of resources. It was indirectly influenced by subject-culture and assessment criteria. The authors concluded the paper with suggestive strategies to overcome the barriers.

Hasalman, Mumcu & Usluel (2008) in their study proposed a 'unified model' to consider all the factors related to integration of technology in the learning environment. After reviewing of the literature available authors described that the concept of 'integration' is quite broad and can be described in various ways. The conclusion that they arrived at suggests that integrating ICT is not simple and yet, it demands due consideration because of its importance in the 'learning process' of the students.

The process of integration is described in two ways: 'technological' and 'pedagogical'. The technological view emphasises due procurement of resources (i.e.

infrastructure) and ‘systems’ in place in the teaching learning environment; the pedagogical view purports the importance of use of ICT as a way to collaborate among learners while providing ‘ICT materials and programs’ (the underlying principle being social constructivism).

The authors also described a sample lesson plan of mathematics with ICT integration from their previous study in 2007. The plan clearly gives importance to ICT as it describes the ICT resources/materials to be used with their desired applications and outcomes. What is to be noted is that the lesson plan also suggests evaluation through rubrics in accordance to the report/ presentations.

To further explore and strengthen the results of the review by them, the authors describe important factors that are imperative to integration of ICT in the teaching learning process; these factors come from the conclusion from their literature review that the “integration process should strengthen the learning of students”.

The model proposed in the paper is cyclic with continuous interaction between the factors broadly divided under : Why, What, Who, How, Where and When for the ICT integration process.

WHY: The most important question teachers face is the need to use ICT in the classroom interaction. It is important that teachers align their teaching with the ICT resources and the content. The reasons authors list are to strengthen the learning process, to develop skills for ‘higher level learning’ and to be able to recognise the difference between students.

WHO: The integration of ICT takes place for the learners/ students in the classroom. Hence, the importance of recognizing the resources and the characteristics of the learners. The aim is not to focus only on cognition and skills developed but also ICT competency. The important points to be considered are ICT and its usage according to the interest and need of the learners; to cater to the individual ‘learning strategies’ and characteristics.

HOW: To answer the question of how ICT can be used, authors use help of the aspects of 'WHICH' ICT resources to be used, 'WHERE' shall they be used and 'WHEN' shall they be used.

- WHICH: The ICT resources and applications to be used need to be in accordance with the pedagogy, 'learning strategy', assessment of the content and cater to the different individuals.
- WHERE: The resources can be placed and accessed from a separate laboratory, classrooms, libraries in schools or from learner's homes. The teachers need to act as guides and give students support. Hence, it is important to understand the role of places from where ICT can be accessed, where the available resources can be used and at during what stage or task students might need support.
- WHEN: For effective and efficient delivery of content in the teaching-learning process, it is imperative to know for how much time these resources need to be used in classrooms for teaching as well as evaluation. And use of which resources should be according to the needs of learners.

The study gives a clear map of how the available resources need to be incorporated in the teaching learning process and what steps need to be taken to integrate ICT effectively. This paper can be used to envision ICT integration in any school or institution.

Mikre (2011) discussed the concepts of integration of ICT, its benefits, limitations for field of education while keeping developing countries in its perspective. ICTs have opened new avenues for both students and teachers to obtain information from different sources. Since, these technologies help in adapting to individual requirements- schools have begun to realise this untapped potential and are using them. According to Tinio (2002, as cited in Mikre, 2011), ICTs help in "absorption and acquisition of knowledge". However, introduction and subsequent integration of ICT in education is a daunting task because of the 'digital divide' between those who have no or limited or full access to technology. The review paper tries to bring to light the practices of certain developed countries so as to encourage other countries to adopt these measures to come at par with the developed countries.

Drawing from different researchers- the benefits of ICT in education were drawn by the author. Use of ICT in education has increased in past 20 years (Volman, 2005 as cited in Mikre, 2011). Also, use of ICT in different subjects e.g. simulations in science led to increase in test scores (Kulik, 1994 as cited in Mikre, 2011). Use of ICT also brings change in the learning; it becomes more constructivist with emphasis on activities and the progress of learning takes place as "learning about computers to learning computers" and "learning with computers" (Volman, 2005 as cited in Mikre, 2011). However, in most scenarios computers were found to be used for word processing' and 'drill-and-practice' (Watson, 2001; Volman, 2005 as cited in Mikre, 2011).

Author also concluded that teachers are an important factor how the technology is used in classroom setting. Kozma (2005) as cited in this paper has given 3 points for consideration of ICT in education:

(1) Students scoring more or learning new skills are important for developing economy,
(2) Teacher's skills (technology and pedagogy) and their attitudes also need important consideration,
(3) Innovation in schools and status of literacy of adults.

OECD's International Survey (2002) as cited in Mikre, 2011 outlines points for consideration by ICT policy makers and leader's usage of ICTs by students and teachers, role of ICT in teaching- learning, development of staff, involvement of other schools and organizations, impediments to use of ICT by schools and resources available to students. Identification of these points will help in evaluation of educational outcomes through ICT. UNDP in 2004 also recognised the importance of ICT educational policies. The focus of policies should be on:

(1) Strategies that use ICT to provide an effective mode of learning for masses.
(2) Teachers should be trained to use ICT in education and should be able to 'transfer' the new skills in other areas
(3) Infrastructure of ICT and its content also needs to be focussed upon
(4) Developing countries need to compensate the lacking features of their educational system through use of ICTs

The author also discussed few ICT projects in different countries, like "Vidya Vahini" in India, EdNet in Vietnam, School Net in Thailand under World Links program managed by World Bank. Other projects discussed in the paper also include WordaNet and School Net in Ethiopia. While recognizing challenges of integrating ICT in education, author also lists limitations of ICT use. These are teacher's attitude towards ICT, high cost of infrastructure and resources and the issues related to student behaviours. There are many hurdles in proper integration of ICT in education from policy level to the classroom level.

Acevedo (2005) in his conceptual paper discusses the importance of using ICT in the secondary school education. During this period, the student is around 12-14 years of age and it is the time when there is 'sufficient cognitive capacity' in students, to know about different learning processes and build on the practices previously acquired. This period is also important as students can 'consciously integrate' use of Information and Communication technologies (ICTs)- as a way of learning especially Internet.

The author discussed the importance of ICT in purview of 3 dimensions (of educational process)- 'learning', 'teaching' and 'educational environment'. Guitert/Coderch (2001 as cited in Acevedo, 2005) lists out few skills which will be valuable in present and future educational environment:

a. Internet, which provides "infinite" sources of information
b. Use of information systems
c. To be able to judge the quality of source of information
d. To know the 'credibility of source of information'
e. To know how to manage the excess information Internet provides
f. To be able to communicate information to others
g. Utilization of time (an important factor)

It is important to revamp the pedagogical practices, using technology, so that the learning is more 'efficient' and 'effective'. In the present scenario, technology keeps evolving and is important to be a 'better learner' than to know how to multiply fractions or to remember the capitals of the world (Resnick, 2002 as cited in Acevedo, 2005).

The freedom to plan the way students learn would work for high school students but may prove to be a burden for younger students. However, secondary school education is the right time to gradually transfer the responsibility of learning to students as (a) this would prepare them for the next step in their education i.e. College- where the responsibility of their learning will be theirs and (b) it would prepare teenagers to 'behave like adults' wherein they have freedom, responsibilities and planning for future in their education and life ahead.

ICTs help create 'learner-centric learning'. They can be used with the traditional ways of teaching by teachers and ICTs also provide several ways that students can be stimulated to 'learn more' and 'learn better'. Teachers can take advantage of ICTs through- using various methods of presenting information, by improving 'multi-sensorial instruction', exploring new ways to interact and to have support systems for students (Peters, 2002 as cited in Acevedo, 2005).

Autonomy of learning through ICT is also an important aspect. ICTs provide opportunities to have economical access to content, ways to communicate within and outside school with teachers and students, experts, etc. Using the benefits of ICT will bring about more change in education when the 'autonomy' of ICT is added to the traditional teaching methods.

Limiting ICT to their role of transmission and access of information is to undermine the possibilities it presents. Resnick (2002) suggests that ICTs are like 'construction-material' which can be used to make videos, robots, etc., citing from own experience at MIT's MediaLab, Resnick suggests the approach of 'learning by doing' for this technology e.g. If students want to play video games- let them create them first. This philosophy can be applied in secondary school education as well. If a teenager learns 'how to learn', he/she will be able to transfer these skills, further- and it will be an 'essential skill for their lives'.

Fu (2013) in his review discussed studies that have implications for ICT in education focussing majorly on its benefits and barriers/challenges in its use. The advantages of using ICT in the present paper have been identified as: use of ICT as a tool which helps students to discover topics, provide solutions and makes information more accessible while engaging them. Since students collect information their own, the learning is self-directed and gives them opportunity to focus on higher order thinking.

The longer the time student uses and is exposed to the technologically based learning environment, the more opportunities they have for engaging in higher cognitive tasks.

Integration of ICT also gives autonomy to teachers, as they design their own content through different tools, which increases their competency of ICT usage as well as enhances creativity in the classroom. A number of barriers have also been identified in the review along-with the strategies for the resolution. These include internal and external factors; external factors like availability and accessibility of resources, planning of instructional activities, support from administration, curriculum, time, whereas internal factors such as attitude, belief, motivation, self-confidence, knowledge, technological skills and perceptions have been identified. The author also stresses on the importance of teacher training for aiding teachers to integrate technology in their classrooms. The review concludes by highlighting that school administration, teachers and students are three important pillars for achieving integration of ICT; the process of integration is an evolving process and doesn't lead to a final outcome.

Byker (2014) presented a review on studies available to discuss the status of ICT usage in elementary schools of India. The three barriers to ICT usage that emerge from the review are: lack of resources, inadequate teacher preparation and lack of understanding of concept of ICT's educational purpose. The studies conducted in the past reveal the dismal state of availability of ICT resources in schools, esp. in rural government elementary schools.

It was found that even if computers were available in schools, the acquisition of basic ICT skills was more emphasized. As a result, ICT/Computers was often treated as an independent subject. The author also discussed that how there is limited understanding about usage of technology in elementary classrooms which is worsened by unrealistic perceptions of ICT usage in real classroom contexts by Indian policy makers. Author suggests that sharing of resources can be done to address the issue of scarcity of computers in schools. For improving teachers' perceptions towards use of technology the author highlights that not a lot of data is available on how teachers are being trained in use of technology in the country, however, different initiatives have been running – and are being run – for training of teachers but no data is available to show effectiveness of such initiatives. The barriers identified in the review for

integration of technology were identified as interrelated and overlook other challenges of an Indian classroom i.e. number of students, availability of basic resources and administrative support).

Fisher, Exley and Ciobanu (2014) while discussing different learning theories in respect of use of technology in higher education, mention behaviourism, cognitivism, constructivism, connectivism, and humanistic theories. They further discuss different approaches to education and place of technology in these approaches in higher education. They conclude that technology enables students to express and share their opinion which eventually leads to creation of new knowledge; it also leads to collaboration which is not limited to their classrooms. It also aids in presenting the content in more engaging and new ways to help create new experiences for students. This can further be used by teachers to support learning for individuals from different backgrounds (i.e., social and economic) and even in promoting accessibility for disabled learners.

Thakur (2014) studied the dismal condition of Government schools of a district in Uttar Pradesh, India in terms of availability of ICT for use. The survey showed that the schools in the district lacked basic computer facilities and teaching was done using the traditional methods. The teachers employed in the schools also didn't have any training for ICT usage. The situation of these schools was found to be poor in comparison to the private schools. This disparity eventually leads to creation of a digital divide. The author stresses that even when a lot of government initiatives and schemes have been launched – the ineffective and slow governance systems hamper the implementation of such schemes. These issues can be resolved by creating a positive attitude towards technology and also by promoting change in the style of governance so that all schools benefit from such projects. Availability of power-supply, computers and internet are basic requirements that are essential in government schools to use ICT. Since the students are from rural background and can't afford computers on their own, schools equipped with such tools will help them learn about technology and its use. Adequate training of staff in using technology will also aid in closing the digital divide amongst students.

Goeman, Leuven, et al (2015) presented the results of MICTIVO 2 in their paper, a follow up study of the first ICT Monitor for Flemish Education (MICTIVO) carried

out by the Flemish government in Belgium to assess the educational policy and impact of use of ICT on education.

The study is divided in 4 components of "ICT infrastructure, ICT competencies, ICT use at micro level (use by students, teachers)" and perceptions towards ICT. It was found that the computers in school were mostly outdated and in terms of expenditure, the money was being spent mostly on Interactive white boards than on laptops or any other peripherals. Software which were available for use in schools were obtained commercially. ICT co-ordinators were present in primary and secondary schools; staff which had the support of a co-ordinator was found to be more confident in using ICT for teaching-learning processes. Students and teachers were found to have a positive perception to use of ICT in education. Teachers considered themselves to have sufficient competency for use of ICT in their teaching-learning process. Also, teachers who were found to be more experienced had more positive attitude to use of ICT. This positive attitude along with more experience and more competence of teachers translated to more ICT usage for preparing for classes and during the classes. Students were found to be using ICT more for leisure usage than for class use.

Social media and games were not found to be integrated in the teaching-learning process. Media when used, was for illustrating content. Teachers who were found to be using ICT more than their counterparts would use different types of media in class. Skills of searching on the internet and higher order thinking skills were found to be correlated to teacher's attitude and knowledge towards ICT use in students. The results of the study stress that teachers have to be aware of "functional and critical digital skills" appropriate for students and should know how these skills can be achieved through their pedagogy. These results stress on the importance of teacher training. The authors concluded that professionals working in the area of education i.e. policy makers, school principals, teachers, etc. agree that ICT needs an important place in education to be able to enhance students' learning.

Wadhwani and Abraham (2017) explored how the teachers were using interactive whiteboards in schools while teaching science. The results of the study are based on observations done in the classrooms. The teachers were observed on the following parameters- the features of the interactive whiteboard they used, the time they took in setting up the board, their ability to work on these boards, and tools frequently used

by them. The teachers were also observed on the parameters of integration of interactive whiteboards in their teaching process. Students motivation, enthusiasm, level of attention and participation in the class when the teacher was teaching through these boards were also observed.

The results revealed that these boards were not being utilized to their full potential by the teachers. The reasons attributed were lack of onsite training and support by the manufacturers. Teachers often didn't use technology due to paucity of time and often don't have enough resources or were sometimes weary. However, during the observations it was found that the teachers were trying to use interactive whiteboards in their lessons, but inadequate training and support act as a deterrent for them. In conclusion, authors suggested providing training to teachers in using different tools available on interactive whiteboards; school support will also go a long way in achieving a better learning environment for students.

The studies discussed in the section have focussed on the understanding of the concept of integration in the teaching- learning process. A lot of work has been carried out on the concept and researchers have tried to discuss the idea in detail along with the considerations for the implementation of ICT in the educational process. Researchers have also tried to present suggestive ways of how ICT can be used in education i.e. as a tool to be used across disciplines or as a separate subject in itself.

For successful integration, studies conducted suggest incorporation of these tools in different subjects as per the need of the area. Models have also been proposed to understand how different factors influence the process of integration; the factors have been defined in different categories like internal/external factors. The important factors that are found commonly in all studies include availability of resources and infrastructure, training of teachers, support by school administration and reaction of students to use of these tools. For teachers, it seems training and time available for implementing these tools in their teaching-learning process are very important factors. Surveys carried out like SITES (Pelgrum, 2001) and MICTIVO (Goeman et al, 2015) present similar stories of ICT integration, despite the difference of about fourteen years. In Indian scenario, the studies show that if on one hand there is lack of resources in government schools, there is investment in technology like Interactive White Board by private schools creating a huge digital divide among students. The

story of our scenario is quite complex as our classrooms deal with lack of resources, the huge number of students in class and lack of adequate training of teachers which makes the traditional teaching challenging let alone- teaching using technology. A lot of initiatives by the government have begun in the country for training teachers and making resources available but no data is available to show their effectiveness. More studies need to be conducted in India on evaluation of such programs.

What is understood from the studies discussed is that there are a lot of issues which we face for successful integration of ICT in our education system; the basic problem of lack of resources or its underutilization, lack of support and administrative issues plague our education system. The studies conducted also show how different factors responsible for integration in ICT are interrelated. But it is imperative that we understand that integration of ICT is not a final outcome but an evolving process due to the nature of evolving technology.

RESEARCHES RELATED TO DEVELOPMENT OF HIGHER ORDER THINKING SKILLS AND RELATED CONCEPTS

Stiggins, Grisworld and Wikelund (1989) in their paper brought forth the issue of teaching 'thinking skills' and their assessment which is quite relevant even, today. In this paper, authors studied the ways classroom teaching was assessed by teachers from classes 2 to 12, for measuring student's higher order thinking skills in subject areas of language, social studies, maths and science. For this purpose, tests designed by teachers were analysed, teachers were observed during classroom assessment (i.e. oral questions) and teachers were also interviewed.

To compare the data obtained for higher order thinking skills assessment activities, Quellmalz (1985) taxonomy was used. It includes 5 types of thinking i.e. "recall, analysis, comparison, inference and evaluation." This taxonomy is quite similar to Bloom's taxonomy.

After analysis of test questions it was found that 'recall' and 'inference' type of questions were common in all classes. Items assessing skills of 'analysis' , 'comparison', were few with the skill of 'evaluation' hardly being assessed. When

these results are compared in accordance to different subject areas, it was surprising to note that assessment in science was mostly based on 'recall', languages had focus on both recall and inference with social studies having more weightage of recall type questions followed by analysis and inference. But, the most surprising results were observed in maths with maximum items falling under the category of inference.

The observation of teachers asking oral questions in class yielded similar results in grades 1-6 i.e. more weightage was on recall. And after grade 6, the questions focused almost equally on recall and analysis with questions focusing on inferring and evaluation of content. Across subject areas similar results as above were observed with comparison and evaluation being largely ignored as skills across class-levels.

Since, the data collected was from the district which had initiated training for teachers to teach thinking skills- it was also found that the teachers who received training were more likely to ask higher order thinking skills questions as compared to teachers who received no training. Similarly, while assessing thinking skills of teachers who had attended even one workshop, their attitude and knowledge towards assessment of HOTS improved.

This study even when conducted more than 20 years ago still finds relevance in today's teaching learning process (especially in case of India). Moreover, the methodology used in this paper can be used with an additional component of ICT integration also to get a clearer picture of activities taking place in Indian classrooms, today.

Chancellor (1991) discussed how maths teachers were enthusiastic about teaching their subject in a pilot program for 'gifted students' in an elementary school. The author discusses how Bloom's taxonomy has been misinterpreted by educators, stressing the fact that to proceed to another level of skills, the first level needs to be achieved. The author also makes a case for using Williams' students' behaviours as a method of assessment of students creativity. Williams' Cognitive factors are based on Guilford's divergent production portion intellect. The author also discusses different math activities for students across different levels and list the skills which will be developed as a result will be based on Williams and Bloom's model. The author also stressed on the fact that all students should be given a chance to participate in activities in groups, as working in groups gives all the students a chance to discover

themselves and their classmates and limiting such activities for gifted students would demotivate the other students and make them lose their confidence. Teachers can help in inspiring the students and help them to utilize their skills.

Lewis and Smith (1993) have tried to shed light on the term "higher order thinking", and at the same time differentiate it from "critical thinking" and "problem solving" in this paper.

They try to enhance understanding of "higher order thinking" in following manner:

(a) Differentiate between views of philosophers and psychologists for higher order thinking
(b) Difference between lower and higher order thinking
(c) Explore relationship between problem solving and critical thinking in purview of higher order thinking.

According to Snow (1964) the field of humanities is associated with philosophy and sciences with psychology. Many have contributed to the education system by stressing on application of "critical thought to pedagogy in our schools" during the middle of the 20th century, such as B.O. Smith (1950s), Robert Ennis (1980s) and Mathew Lipman (1980s).

While philosophers argue the importance of logical reasoning and thinking, psychologists focus on thinking process and how experiences can help in construction of meaning from them i.e. problem solving. However, it is noteworthy that both the methods (problem solving and reflective thinking and logic) are necessary but neither would suffice for in-depth understanding of higher order thinking.

The authors also draw on works of Maier (1933), Bartlett (1958), Resnick (1987) and Newman (1990) to provide distinction between lower and higher order thinking. Maier uses the term "productive and reproductive thinking"; Bartlett uses the term "interpolation" and "extrapolation". It is important to understand that lower and higher order thinking are relative. While one situation may require higher order thinking by an individual, it may require lower order thinking by another (Newman, 1990 as cited in Lewis and Smith, 1993). Lower order thinking requires "routine, mechanical application" while interpretation, analysis or manipulation of the

information is the essence of higher order thinking. The teaching of the two in the classroom situation may be interwoven (Resnick, 1987).

Drawing on works of Beyer (1985), Ennis (1980s), Facione (1984) and B.O. Smith (1991)- the paper posited that problem solving and critical thinking have separate domains. Terms like problem solving, critical thinking, reasoning, thinking skills are often defined in terms of each other, hence Cuban (1984) calls defining the terms as a "conceptual swamp". According to Benderson (1990), "philosophers stress the need for critical thinking, while psychologists prefer the term thinking skills".

An encompassing term for critical thinking, creative thinking, problem solving and decision making has been suggested by Smith and Lewis - "higher order thinking".

"Higher order thinking occurs when a person takes new information stored in memory and inter- relates and/or arranges and extends this information to achieve a purpose or find possible answers in perplexing situations." (Lewis and Smith, 1993)

The paper concludes by suggesting implications of higher order thinking for teachers in classrooms i.e. importance of Higher order thinking for every individual. For its assessment it is important to test with situations that cannot be responded-to through simple recall of information and it is important to pursue higher order thinking even for students with learning difficulties. The paper also stresses the importance of involving higher order thinking skills in in-service as well as pre-service teaching programs.

Raudenbush, Rowan and Cheong (1993**)** tried to bring out the factors which influence the teaching of higher order thinking (based on the context of U.S. Secondary classrooms). They consider 3 variations for the same, namely:

a) The concept of teaching HOTS limited to 'high track students' in the advanced courses
b) Teachers preparation not adequate for teaching HOTS
c) The organizational structure (educational structure, education policies, etc.) does not provide conditions to pursue HOTS

Data was collected from classes of English, Science, Social Studies and Maths from 16 schools. Regression analysis was used to study effect of the 3 variations across the 4 subject areas. In the early 1980s to 1990s, the researchers began to consider higher order thinking as an important goal for education. According to report of U.S. Department of Education (published in 1991), it was found that found that the students were performing well in testing of basic skills but poorly on tasks of "problem solving, critical analysis and flexible understanding of subject matter".

Despite agreement on importance of higher order thinking, it was found that classrooms focused on basic skills (Goodland,1984; Powell, Farrar and Cohen, 1985 as cited in Raudenbush et al, 1993).

The authors tried to find reasons for variation in teaching of higher order thinking skills in U.S. schools (in 16 schools in California and Michigan) by considering following perspectives (in accordance to hypothesis) together-

(a) Teaching of higher order thinking will be emphasised in
   - Higher classes (or grades)
   - Better performing class (with higher academic track)
   - Effects of track and grade will be more on Maths and Science as compared to English and Social Studies

(b) Teacher would emphasise teaching of HOTS if :
   - Teacher's level of education is high
   - More years of experience
   - Better preparation for teaching a course
   - Achievement in class is not the basis of judging the quality of his/her teaching
   - Coverage of syllabus/ curriculum is not emphasised
   - Support is provided by administrators and teacher has control over policies in areas of curriculum and instruction.

The important consideration in the paper is that "higher order thinking" has been taken as domain specific for different subject areas rather than a generic skill. The results obtained after multi-level regression across different subject areas suggested that there is a strong link between the "track" of the class and importance given to higher order thinking especially according to different subject areas especially in

maths and science. Moreover, these are the disciplines wherein the level of class/grade made the difference.

In English and Social Studies- teacher's preparation for a class also made a difference. Teacher's level of education was found not related to his/her preference to teach higher order thinking skills. However, the school's support and organization was found to have a positive effect on teaching of higher order thinking. Authors urge to have a multilevel analytical approach to gauge the contributing factors at school, class and teacher level.

Terenzini, Springer, Pascarella and Nora (1995) assessed the influence of 3 factors i.e. exposure of curriculum, instructional &classroom experiences and out-of-class experiences on critical thinking of college students. National Education Goal Panel of 1991 (U.S.) also emphasises the importance of critical thinking skill which authors call an "enduring skill", important for lifelong and meaningful learning.

Pascarella and Terenzini (1991) as cited, inferred that there was not much ground to show that instruction influences critical thinking probably as a semester long course is not sufficient, to show any amount of its effect. However, greater measure of critical thinking is found when a number of courses are taken (Dressel and Mayhew, 1954; Pike and Phillipi, 1988; Pike, 1989; Pike and Baata, 1989 as cited in Terenzini et al, 1995). 'Inter-relatedness' of courses undertaken also influence critical thinking ability. Students who are doing a course that promoted cross-discipline integration of ideas also showed more gains in critical thinking (Winter, McClelland and Stewart, 1981 as cited in Terenzini et al 1995). Authors also concluded from literature available that critical thinking is influenced by important factors such as encouragement by teachers, the cognitive level of students, the interaction between students and interaction of students with teachers (in class and out of class).

Pascarella's study from 1989 as cited, suggests that college experience is more inter-related rather than being specific to any particular kind of experience for gains in critical thinking ability. The present study was longitudinal of 1 year duration. The data was collected by CAAP (Collegiate Assessment of Academic Proficiency) form 88B followed by CAAP 88A and CSEQ. 'Critical thinking skills' was the dependent variable identified with:

- “Parent’s education
- Family income
- Age
- Sex
- Degree planned
- Out-of-class experiences
- Class-related experiences
- Courses opted for”

As independent variables (these independent variables were identified after reduced-model regressions obtained from CAAP critical thinking scores). The findings indicate that critical thinking ability of students is affected by both in an out of class experiences of students. It is difficult to point at a particular factor affecting critical thinking ability- there are multiple sources affecting it.

Zohar (1999) discussed a qualitative study, conducted on in-service high school teachers of Israel who were participated in the TSC program (Thinking in Science Classroom). The paper discusses teacher’s metacognitive knowledge in regard to HOTS. Huge investment is being made around the world to develop program and strategies to inculcate, to cultivate ‘thinking skills’ in students. However, for success of such program teachers are highly accountable. It is imperative to understand awareness and knowledge teachers have regarding such programs.

Importance of metacognition (awareness of one’s own cognitive process (Flavell, 1976)) of higher order thinking program is stressed for teachers; if teachers are aware of such skills themselves, they will introduce them in class, these skills are important to teach and will be helpful in making students proficient in “higher order thinking”.

Metacognition can be taught as part of direct training or transferred spontaneously. In the present study the concept of ‘metacognitive knowledge’ was studied in context of Thinking in Science (TSC) project (as cited in Zohar, 1999; Zohar, Weinberger and Tamir, 1994; Zohar, 1996). Higher order thinking skills were taught as a part of the science subject; various activities were used to teach students like inquiry and critical thinking skills, questioning/arguing skills and open-ended discussions. Interestingly,

the students were not aware that they were being taught ‘thinking’, since, the activities were integrated in science teaching.

TSC includes activities which begin teaching a topic with problems and student’s reflecting on them rather than transmission of knowledge. After a period of time when students are again and again practising the skills they become proficient in metacognition by being able to “reflect on thinking process, able to identify similarity in problems, analyze the problem and decide to use a particular method.”

Data was collected from high school teachers participating in the TSC program. The results showed that even if teachers were using ‘thinking skills’ in their lesson, they were not aware of terms for them and they were able to structure and arrange their lessons well.

Author also compared data obtained from 2 TSC courses of 1995 and 1996. At the end of the first course the teachers were yet to become proficient in using “metacognitive declarative knowledge” despite them creating their own activities. Once, the teachers were asked to describe the thinking activities as a part of their instructional objective- they become more aware and stressed “higher order thinking” as a part of their lessons (i.e. learning activities). The findings of the study showed that teacher’s “intuitive declarative metacognitive knowledge” was not satisfactory for teaching science.

Even though teachers are aware of Bloom’s taxonomy of teaching objectives, active use of these in planning of lessons will help in making teachers more aware of the thinking skills especially higher order. What is needed is that teachers actively use strategies to foster higher order thinking skills in teaching, which in turn help in development of metacognition.

Sparapani (2000) while stressing on importance of revamping the teaching-learning process for individualised instructions, discussed a Thinking Learning system (developed by Sparapani and Edwards, 1996) to be used by teachers for classroom instruction. Teachers are often concerned about their students and their level of achievements, which reflects on teachers themselves and their school. More often because of the focus on results of standardised assessments, teachers are unable to move from their role of “dispensers of knowledge”. Even if teachers realise that a

change is required in the way they teach, they are unable to decide on how it needs to be done. Even if the teacher does manage to change their teaching methods, the emphasis on results by stakeholders of the system hinders their progress.

In the present study authors asked teachers from elementary to college level (all subject areas) to teach using a T/L system. Through this system, the lesson plan/activity was divided in four parts - information processing activity, critical thinking activity, decision making activity and creating thinking activity. Data was collected from teachers during two semesters (Fall '97-'98) and was analysed on basis of "variation of situational analysis case study design" (Borg and Gall, 1993 as cited in Sparapani, 2000). After the lessons were taught, qualitative data was collected through an interview of teachers and evaluation form of the lessons focusing on strengths/weaknesses of the lessons, changes observed in behaviour and attitude of students and in self, summarisation of activities taken place and feedback given to the students. The teachers responded that they had spent more time in planning and designing the lessons which had focussed on real world application. Teachers also realised that teaching in this manner made students aware of relationship between different subjects. Despite the classrooms becoming noisier (owing to activities), the level of cooperation in students increased. Teachers reported that apart from textbooks, there were hardly any other resources for students and teachers and it was often difficult to coordinate with computer and library facilities.

The results of the study show that teachers realised that planning activities for higher order thinking skills took more time as well as resources; the assessment techniques were also to be aligned with the new activities. Higher order thinking activities help students to be more independent and creative learners.

Zohar (2004) in his paper dealt with a qualitative study based on grounded research wherein the thinking in science classroom (TSC) project's professional development courses were used to collect data from teachers regarding their "pedagogical knowledge" of higher order thinking.

The study focussed on "pedagogical knowledge" of higher order thinking as a direct instructional goal. The author defines higher order thinking according to Bloom's Taxonomy (1954). Reference is also drawn from Resnick (1981) who asserts that higher order thinking cannot be defined by using specific terminology. With all the

literature available- higher order thinking is often an overlapping- term; with different parameters defining the same term. Hence, Resnick suggested that such a term should be characterised.

For the study conducted, the author divided the supporting literature in 2 ways, first dealing with teacher's own higher order thinking and second, teacher's perspective on higher order thinking as a part of their pedagogy. The evidence suggests that teachers lack the understanding of concepts of thinking/critical thinking. They may have procedural knowledge of solving problems but their metacognition for higher order thinking was lacking (Zohar, 1999). Teacher's also lacked knowledge about teaching higher order thinking and consider higher order thinking as a goal for higher achieving students.

Participants of the present study were Israeli junior and high school science teachers who were also participants of 5 TSC courses. These were in-service courses where teachers discussed problems of teaching, implementation and specific materials (part of TSC course) for higher order thinking. The data constituted of activity sheets, teacher's reflections and discussions.

The results from the activity sheets (which comprised of teacher's responses to a videotaped lesson in which a student tries to solve a problem) were classified broadly in 2 categories in which first involved giving detailed instruction to students or asking 'directive questions' and second involves asking questions that lead student to a 'conflict' or to not intervene in the problem solving stage of learning process. Of the respondents, 2/3 believed to not to challenge student's thinking and they preferred in reducing the 'cognitive level' of the task to series of steps.

The study concluded on the note that all the data points to a basic difference of teaching pedagogy (for higher order thinking) that whether it is to be taught in traditional method by transmitting knowledge or in a constructivist way. Most of the time curriculum is the centre of instruction. Moreover, even when materials with different instructional goals are given to teachers they teach them in traditional manner because of its unfamiliarity (Bruer, 1993 as cited in Zohar, 2004). Thus, it is important to focus on basic instructional theories of teachers. This can be done during pre-service and in-service courses. In order to teach higher order thinking to students,

issues related to teacher's pedagogic knowledge about teaching them need to be dealt with.

Although the study brings out important issues for teaching higher order thinking skills, it is limited only to Israeli science school teachers who had been under the TSC programme.

Moseley, Elliott, Gregson and Higgins (2005) attempted to conduct an evaluation and review of 'thinking skills' taxonomies and frameworks with special reference to learning after 16 years of age (post- 16 education in British context).

The authors use the term 'thinking' loosely in context of 'thinking skills' and highlight skills involved in 'thinking skills programme' according to Ashman and Conway (1997) in following manner:

- "Metacognition"
- "Critical thinking"
- "Cognitive processes"
- "Core thinking skills"
- "Understanding role of content knowledge"

The purpose was to be able to identify and understand that how can thinking skills be developed, on what factors they depend and how can their development be enhanced in the education process by helping in areas of instructional design, lesson planning, assessment, etc. Authors identified 55 thinking skills frameworks after extensive research and divided them in 4 families i.e.

(1) "All-embracing family for theories and models of personality, thought and learning
(2) 'Designer family' theories and models for instructional design
(3) 'Higher order family' theories and models of 'productive' and 'critical' thinking
(4) 'Intellectual family' theories and models of cognitive structure and development"

Out of these 55 frameworks, 35 were selected. It was found that during the period of 1960s-1980s behaviourist theories were common and only after this period- the focus shifted to "metacognition", "self-reflection", "self-regulation", etc. Mostly the frameworks focus on understanding, elaboration and information known towards building outcomes.

Authors also considered Marzano's (2001) taxonomy of educational objectives for recommendation as a single framework but was not used because of the disadvantages that this framework had; it did not have "reasoning" and "creative thinking" under the "knowledge utilization" purview. Moreover, the terms Marzano uses varies from the common usage in other taxonomies. However, on the other hand authors identified 3 frameworks as more relevant- Halpern (1997, 2002), revision of Bloom's taxonomy by Anderson and Krathwohl (2001) and Pintrich (2002). These frameworks have wide range of applicability for wider age group and take in their purview the recent developments in the field.

Authors go on to put together a framework with consideration of 7 frameworks (by Halpern (1997, 2002), Pintrich (2002), Sternberg (1986, 2003), Ennis (1987), Paul (1990, 1993), Lipman (1991, 2003) and Anderson and Krathwohl (2001)) which depicts an "integrated model for understanding thinking and learning".

The authors conclude on the note stating that meaningful learning occurs if the thinking is "strategic and reflective". Because of the intensive study carried out on 35 theoretical frameworks, the model proposed by authors is equally valuable for researchers and teachers to develop more in depth knowledge of the teaching-learning process.

Yildrim (2007) brought forth the perception of school teachers towards the teaching of thinking (theoretical understanding) and also whether they accepted a 'content-based' or 'skill-based' approach for teaching thinking.

Teaching children how to think is an important goal of education. Educators were found to be divided in their views that which theoretical approach is better for teaching thinking. One view was of 'content based' thinking in which thinking skills are not taught explicitly and directly. If the subject matter involved "thoughtful subject matter in instruction" wherein students had to reflect rather than memorize

facts- “in-depth understanding of content” it would help in development of higher order thinking (Prawat, 1991 as cited in Yildrim, 2007). The other view was teaching through skills, in which the specific skills were to be taught explicitly by the teacher. The teacher may also show the ways in which students can articulate the skills. A questionnaire was used in the study to bring forth the opinion of teachers regarding both the approaches. This questionnaire had 20 statements based on the two theoretical approaches i.e. skill based or content based methods for teaching thinking; the 5 point Likert scale was subjected to 600 school teachers out of which 285 were returned to the researcher.

The results indicate that the teachers realise the importance of both the approaches and would rather use an “eclectic approach”. Researchers oriented towards content-based teaching of thinking argue that the content available to teachers in different subject areas provides the best medium to teach thinking. Results from the questionnaire also indicate that the teachers view ‘subject-specific content’ as an important facet in ‘improving student thinking’. This also implies that certain thinking skills would be specific to certain subject areas.

Researchers oriented towards skill-based teaching of thinking suggest that these skills should be taught “explicitly”, “without an interference” of the subject-specific content. Teachers supported the view that direct instruction of skills like “problem solving, analogies and analytical thinking” would largely benefit the students. It would help students to “identify mental steps” as the solve any problem.

After division of sub-scale scores of the questionnaire, the researcher found that the respondents to be equally divided in their opinion. The results showed that the teachers are aware that ‘thinking and knowledge’ are inner related. They also realized the importance of teaching thinking skills through subject matter and at the same time, that it is important to make students aware of the process or experience those thinking skills. The implications of the research include both the content based and skill based approaches need more exploration; the gap between the program designers (for teaching thinking) and the teachers needs to be filled.

Supon (2009) in this paper described the importance of teaching students to think critically. Teachers through the teaching –learning process have been egged on by researchers, parents, leaders, employers to teach students “to become critical

thinkers". In present scenario this emphasis can be related to globalisation and changes it has brought in our society, education and occupations.

A few factors which are obstructions to the realisation of goal of making our students 'critical thinkers' have been identified as:

1. Teacher's inability to 'think critically' themselves
2. Reluctance of students to share their experiences because of apprehension of being ridiculed
3. Inability of teachers to innovate teaching so as to inculcate critical thinking

Author enlisted 5 broad categories wherein teachers would be able to overcome the fear or obstruction of teaching critical thinking:

a. In a classroom setting, teacher is the role model for students. If the teacher becomes aware of or conscious towards critical thinking and improve them- they will be able to guide their students better. Enriching their repertoire by consulting books, reading journals will help teachers to teach in innovative manner. The change in their attitude will make them relate more with their students.
b. Creating a 'non-judgemental' environment in classroom will go a long way in helping students inculcate 'critical thinking'. Classroom discussions and collaborating with each other, will help students to empathise more among themselves and with the teachers. This environment of respect will encourage students to share their experiences.
c. Using different techniques of teaching like role playing, journal writing, mind mapping, discussions, visualising concepts or ideas. will help students to share information with one another and also generate their interest.
d. Lesson plans which include not only completing homework or a worksheet but have students involved in variety of activities, should be constructed by the teacher. Once the teacher starts modelling 'reflection' in his/her classes, they can encourage students to do the same. Students are eager to learn new ideas and thus, involving them in 'comparison, validation, reconstruction of their ideas' will go a long way in developing their higher thinking.

e. The activities which gives opportunities for spontaneity- help students/learners o build new perceptions and involvement with other students i.e. cooperation will help evolving critical thinking ability.

Teachers need to be deliberate while constructing activities which help in building higher- thinking ability; integration in the curriculum and using visuals, etc. help in stimulating the environment. The effect made by teachers will show effects 'beyond the classroom' as well.

Limbach and Waugh (2010) aimed to identify a 5 step interdisciplinary process of developing higher level thinking skills in their paper. It is built-upon existing theory and best practices in cognition and effective learning environments. The five steps identified are: (1) determining learning objectives, (2) teach through questioning, (3) practice before assessment, (4) review, refine and improve and (5) provide feedback and assessment of learning. For the successful implementation of this process teachers are required to make changes in the pedagogy and create a student centred learning environment.

The steps discussed in the paper are simple and effective but require dedication from the teachers. Learning objectives form the basic building block of a lesson plan and from here the teacher has to identify the key objectives for learning and recognise what students know and what have they learnt. Such learning activities need to be designed which engage the student and help them practice, critique and question everything. This ability to question and analyse, aid in development of higher order thinking skills. Continuous refinement of the course and content is required to ensure that the teaching methodology is aiding students in developing higher order thinking skills. The change in instructional method might pose problems for the students as well as the teachers but in the end it will be beneficial.

Kong et al (2014) presented the research issues and policy implications for e-learning in school education for the coming ten years. The focus of the review was development of 21st century skills. Also, the six issues for the research were identified as: developing 21st century skills in learners, designing curriculum which is related to societal contexts, maximizing learning opportunities, collecting evidence of improvement and process, assessing 21st century skills and ensuring teacher

development for these skills in students. The authors emphasized on joint efforts by policy makers, researchers and practitioners to achieve the vision.

The school leadership has to be trained for recognizing the benefits of e-learning in students so as to give them focus to be able to plan for integration of technology and e-learning in their schools. Technology can be used to create environments which is contextualized to today's scenario and give students authentic learning experiences. Teachers need to be trained and supported to alter their pedagogy to incorporate technology and then they can engage learners in an interactive and constructive process of learning. Teaching through technological tools for 21st century skills should be followed by assessment suited for such a teaching-learning process. Studying such learning environments which have successfully incorporated technology will help researchers to explore and address any issues. This will lead to collection of evidence and creating awareness in learners about pedagogy and assessment techniques in their schools.

The authors concluded the paper with stress on importance of policy to guide the efforts for inculcating 21st century skills in the right direction. Policies to address any issues such as curriculum, learning outcomes, resources, privacy/legal issues and teacher development will go a long way to achieve the goal of developing 21st century skills in students.

Arnold (2015) in his action research on teachers in London schools tried to find out the way ICT is being used by them. In his study he explains that ICT is being used in a "simplistic way" i.e. Interactive boards is a digital counterpart of the chalkboard. The teachers are using this technology in existing approaches and are not analysing o synthesizing their knowledge of ICT to create new approaches for their usage in the teaching- learning process. Teacher who did not use ICT in their curriculum (during training) struggled to integrate it in the pedagogy.

Kong (2015) in his study described the development of 'critical thinking' during a course of 3 years using 'flipped classroom strategy' (trial teaching). The sample for the study was junior secondary students. The strategy was integrated in 'Integrated Humanities' subject with emphasis on both pedagogical and technological aspect.

The ‘flipped classroom strategy’ involves an ‘online pre-lesson learning’ by students before the lesson beings in classroom; during class students and teachers discuss using ‘lesson learning’ and after lesson students engaged in ‘post-lesson learning’. All this was supported through mobiles used by students.

The dimensions focused under the purview of ‘critical thinking’ for the present study included: hypothesis, induction, deduction, explanation and evaluation. Worksheets were developed to help assimilation of critical thinking skills in students through “embedded scenarios” on specific topics. To assess critical thinking, Yeh’s instrument was used which had 25 multiple choice based questions divided according to the 5 dimensions of critical thinking.

Semi-structured interviews were conducted on both students and teachers during the 3 years and it was found that there was increase in competency in one out of five dimensions of critical thinking during the first year; second year was important as during this period the levels across all dimensions increased and in the final year it still showed significant improvement. Even though, students showed improvement across all the three years; the increase in the second and third year could be attributed to increase in opportunity to practice more questions on critical thinking.

Previous findings by authors suggests that secondary students were competent in hypothesis identification and deduction but relatively weak in explanation and evaluation. This conclusion was found to be true in this case as well wherein explanation and evaluation skills were difficult to develop by junior secondary level, however, the improvement is these skills was observed in year 2 and 3 along with that of deduction.

Tan and Halili (2015) stressed on the importance of teaching HOTS and how it faces a lot of challenges. They discuss how higher order thinking is a concept more than Bloom’s Taxonomy. Other concepts related to it are “Critical Thinking, Creative Thinking, Problem Solving, Decision Making and Meta-cognition”. Authors also discussed how HOTS can be taught in class. According to the research quoted in the paper, HOTS receive little or almost no attention from teachers; teachers are more focussed on pursuing goals set for specific content. Discussing the Malaysian scenario, authors mention that in accordance to researches done, classrooms in

Malaysia are still dominated by lower order thinking. For teaching HOTS literature has identified two ways – Infusion or as a Separate Subject.

Authors also discuss the challenges which teachers might face while teaching HOTS. Teaching HOTS is a time consuming process and with strict schedule set for classes teaches might find it difficult to teach HOTS in a limited time. Teachers may also find it difficult to motivate students to use their thinking skills for different tasks, here the planning of lessons and availability of resources acts as a positive factor for engaging learners. Teachers also need to create an active learning environment for students and assessment strategies should be planned in accordance with activities being used to develop HOTS. As discussed in the paper, teacher plays an important role in developing HOTS in students, it is imperative that teachers are sure of concepts of the HOTS and realize their goals of teaching in accordance to them.

Stress on HOTS or higher order thinking skills, which has been dealt with different terms in literature, was brought to focus in mid 1990s wherein there is a lot of discussion of the correct term for the concept. Later with the advent of technology revolution in education in the 21st century, the term used in literature reviewed is "21st century skills". Although this concept is broader, it is made up of several other skills but it mentions critical thinking, problem solving and creativity as skills required by learners to survive in the highly competitive world.

The term higher order thinking was used in Bloom's taxonomy (1956) and as a concept includes analysis, inference, evaluation skills which are common to critical thinking as well. There is an ambiguity over the use of these terms and Lewis and Smith (1993) tried to resolve the issue by suggesting that psychologists use the term higher order thinking and philosophers relate to the concept as critical thinking. This concept has been suggested to be a relative one, with no clear distinction possible between different levels of cognition in students. There is also a debate on whether this concept is general or domain specific. Studies show that teachers would prefer to teach these skills through an eclectic approach.

The papers mentioned above discuss what factors influence inculcation of higher order thinking skills in students and what inputs are required for their successful

realization. The review reveals that these skills are developed when teachers are trained for teaching these skills and are aware of how these can be taught to their students. However, teachers also hold the conception that these skills are only for "gifted students"; this in itself acts as a demotivation for students. Other factors also influence the development of these skills in students like interaction among peers, interaction with teachers, age and cognitive level, gender, subject domain, etc. Teachers training to teach these skills has been found to be effective but these skills are seldom focussed as preparing lessons with activities for catering higher order thinking skills, take a lot of time. Zohar (1999) found that even if the teachers were teaching these skills, they were not aware of the correct term for them. And when such skills are taught in class, the assessment needs to be aligned to the objective, which presents the need to revamp the curriculum for achieving these skills. Studies show that more often than not it has been found that teachers tend to focus on recall and inference type questions and mostly, recall during oral questions. The skill of evaluation is hardly focused on. To develop these skills in students, teachers need to be aware of these skills; for successful development of such type of skills- teacher training should focus on these skills and teachers should be able to devise strategies wherein they can emphasise and develop these skills in their students.

FACTORS INFLUENCING USE OF ICT BY TEACHERS AND STUDENTS

Hennessy, Ruthven and Brindley (2001) examined how secondary school teachers teaching Mathematics, Science and English integrate information and communication technology (ICT) into mainstream classroom practice in schools. The paper investigates how the technologies – specifically digital – aid accomplishing already familiar activities more productively, broadly, quickly, reliably, interactively and how such usage could be reshaping these activities. It analyses teachers' conceptions on whether their use of ICT has a motivating or constraining influence. The analysis concludes with a grounded model of how technology usage could be successfully exploited and integrated into existing classroom practice, and how its practice is evolving.

In the paper, the implications of introducing a powerful set of cross-curricular tools and resources for the traditional academic curriculum were considered, along with the influence of established curriculum policy and practice upon teachers' willingness in developing new forms of pedagogy and activity. The paper drew on an analysis of 18 focus group interviews with core subject departments. The analysis concludes with a thematic model of professional thinking, illustrating how a subject's learning and teaching can be supported by integrated use of ICT.

Teachers' opinions emphasize the use of ICT to extend and enhance existing teaching-practices in classroom, and introduction of activities complementing or to modify existing practices. What's apparent here is that pedagogical evolution is a gradual process; teachers are trying to (and even developing) new strategies specifically for mediating ICT-supported learning.

Watson (2001) in his paper focused on the most relevant question that why, in this era of globalization, ICT has failed to make impact on education as it did in business and everyday living. Focusing on U.K.'s activities in education as case study, the author of the paper tried to answer the quintessential question. ICT is not only perceived as a driver of change in accessing information but also on teaching and learning styles. Early decades saw growth of importance of computer assisted learning and later with the advent of web technology, the focus shifted towards learning through it. The author also focuses on a "dichotomy of purpose" which highlights lack of clarity on focussing on ICT as a subject on its own or ICT as a tool. Learning about ICT has been identified as a 'vocational purpose' and learning with ICT has been identified as a 'pedagogic purpose'. One of the problems identified which hampers the revolution in education is that of considering ICT skills in isolation. Teachers and staff have been reluctant in using technology; even if training has been provided it results in little or change in usage of ICT to improve pedagogy. The author also considers Passey's (1999) analysis which shows that most of the learning objectives focus on lower order thinking skills rather than on higher order thinking skills like analysis, synthesis and evaluation. The paper concludes that teachers are drivers of change; their focus should shift from teaching the subject to teaching the children.

The paper aptly discusses the importance of reforming pedagogy to incorporate technological advancements in education. It also rightly identifies that teachers need

to harness the technology to develop new higher thinking skills rather than using ICT as a tool to simply assist then in the teaching-learning process. However, the paper lacks in the perspective of placing importance to teacher training programs and their onus to prepare teachers to reform their pedagogy from grass-root level.

Becta (2003) published a report to help identify the barriers which affect the use of ICT in classrooms. These barriers were identified as lack of time, lack of self confidence in teachers to use ICT, fear to use technology in front of students and possible failure to troubleshoot, class management issues while using technology, lack of motivation and perception that technology doesn't help students. Certain barriers were identified at school level as well, i.e. lack of resources, accessibility issues, maintenance issues, lack of administrative and technological support and lack of training of ICT usage as per teachers' requirements and more importantly, lack of training in integrating technology in classrooms. The report concurs to the literature available on barriers of use of ICT.

While discussing the barriers, authors defined them as external and internal, and demonstrate it is difficult to differentiate amongst the two as often the two types of barriers might influence each other. External barrier have been referred to resources and support to use ICT, while internal barriers referred to teacher-level or school-level issues. Garnering positive attitude and training of teachers can help in addressing the barriers to ICT usage.

Bebell, Russell and O' Dwyer (2004) bring the focus to teacher's role in use of technology through 'composite' and 'multiple measures' across 7 areas of: Use of technology in preparing lessons, e-mailing (for professional purposes), for delivering instructions (in classroom), for accommodating (different learners), use by student (teacher- directed), yielding products and use in grading students.

The paper used data collected as part of USEIT study (conducted in Massachusetts), the study aimed to collect data from both teachers and students about their use of technology how it effects learning of students. In the present context the focus is on teacher's usage which was studied on the basis of previously mentioned 7 areas. The frequency of usage across the 7 areas with their respective tasks were outlined. The analysis of the results was done in two ways (1) composite measure, which is the total score (of frequency) of usage across all the areas (2) multiple measures, which

involves observing the frequency across different areas and their respective tasks. Composite measure showed that usage of technology was 'normally distributed', however multiple measures showed that the responses were distributed variably across all areas. The usage of technology was found to be in the following descending order – Preparation, Emailing, Teacher-directed use by students, Grading, Delivering instruction, Accommodating learners and Student products. The above results were co-related, by authors, which yielded positive results showing that usage in one area will lead to usage in other areas as well. To further probe the results, authors co-related these findings by bringing number of years of experience of teachers, type of school (middle or elementary) and subject areas into consideration.

The results show that in generic terms both experience of teachers and integration of technology across subject areas (English, Social Studies, Science, Mathematics) was similar (i.e. normally distributed). Although, further analysis by 'Multiple measures' showed that newer teachers used more technology for preparation of lessons and for accommodating different learners as compared to more experienced teachers but used less technology as compared to them for delivering lessons and assigning tasks to students involving use of technology in class. Similarly, it was found that Mathematics teachers tend to use less technology as compared to other subject teachers with the other subject teachers showing similar level of usage of technology. The multiple measure method helps draw focus on different aspects of technology usage in schools. It shows that integration of technology is a complex issue, varied across different schools.

Afshari, Su Luan, Samah & Fooi (2009) discussed about the various factors which prevent or affect usage of ICT by teachers. Even though computer technology is largely talked about and used in educational institutions these days, lack of positive attitude of teachers or lack of their ICT skills are considered as major drawbacks in implementation of technology in schools. The paper reviewed factors which influence teachers' decisions to use ICT in the classroom and highlighted the models being used or developed for integrating technology in teacher training programs. The factors are broadly discussed as Manipulative (like attitudes of teachers towards ICT and teaching, ICT knowledge and skills) and Non-Manipulative (like age, teaching experience, experience of teacher, government policy or external support for schools) factors. The paper concludes that no single factor in isolation affects the integration of

ICT. School related factors and teacher factors are interrelated. However, teacher training programs can greatly bring about change as they prepare teachers and provide necessary skills to them according to the needs of the society.

The paper largely draws on research of Ten Brummelhuis (1999-2000) and discusses the manipulative and non-manipulative factors. Manipulative factors as studies by the present paper are school's vision and contribution towards ICT, availability and accessibility of ICT infrastructure, lack of assigned time for developing and reflecting on ICT skills, support available to use computers, school culture, level of teacher training, attitude towards computers, ICT skills and training programs. The paper identifies all the major factors responsible for ICT implementation; these manipulative factors can be easily controlled. The two major non-manipulative factors discussed are teachers characteristic and parent and community support.

Voogt, Knezek, et al (2011) deliberated upon the question "Under which conditions does ICT have a positive effect on teaching and learning?" The paper is a discussion on the agenda which directed the EDUsummIT, 2009. The authors at length discussed the major factors which affect the use of ICT in the teaching and learning process and proposed eight actions which are discussed in the paper in relation to the teaching-learning process, involvement of teachers and schools and promotion of equity in practice, along-with policies. While discussing the teaching learning processes, authors emphasized that to achieve 21st century learning use of ICT is required. The learning in the classrooms needs to be student centred; the pedagogy used in the classroom is often more focussed on outcomes which are more suited for an industry rather than on development of thinking in students.

Use of ICT tools presents a support to learning as well as educational goals. Its usage affects students' learning as they can access in-depth information of concepts. Authors cite work by other researchers and suggest that curriculum of schools needs to be revamped to integrate technology. Providing support and training to teachers will help them develop their skills to use ICT in their teaching process and help teachers to use ICT tools in an innovative manner.

The authors also mentioned that the recent studies show that students who have grown up with technology tend to use more technology in different tasks in comparison to "digital immigrants". Involvement of school and teachers are imperative factors for

active use of ICT. Teachers' attitude and their skill and access to ICT tools are important for teachers to help them incorporate ICT in their teaching-learning process. Usage of ICT has been found to promote positive attitude of teachers, however with knowledge of tools, esp. their pedagogical use is essential to observe any change in educational practice.

Schools play an enabling role as better access to technology translates to more usage, which affects attitude towards use of technology. A policy at school level will either promote or hamper the use and implementation of technology which will eventually guide the process of integration. When schools invest in ICT tools they should be guided so as to have basic infrastructure in place as essentials like electricity, network connections, phones, hardware and software for secure schools buildings is the basis for introducing technology in a school. With such researches collaboration among practitioners and researchers can be built which will benefit the stakeholders in the process.

Hsu (2011) in his examination of relationship of ICT usage of teacher and student in Taiwan, found that there is a positive relationship between the two. The more proficient a teacher is in using ICT tools, the more he or she is likely to involve such tasks in their assignment. The usage by students and teachers are to be considered as individual entities. The reason for low ICT integration is that often the two use cases i.e. for teachers and students are considered as same and teachers often take a longer time in becoming proficient in using of ICT tools; this proficiency is dependent on their previous experience and training and teacher needs "more constructivist oriented pedagogy" with a more openness in attitude.

Buabeng-Andoh (2012) discussed how different factors influenced teachers integration of ICT, in his review. Many governments across the globe are investing in ICT to improve teaching and learning in schools. Despite all these investments on ICT infrastructure, equipment and professional development to improve education in many countries, ICT adoption and integration in teaching and learning has been very limited. This article reviewed personal, institutional and technological factors that encourage teachers' use of computer technology in teaching- learning processes. Also the factors that prevent use of ICT at teacher-level, school-level and system-level have been reviewed. These barriers include lack of teacher ICT skills, lack of teacher

confidence, lack of pedagogical teacher training, lack of suitable educational software, limited access to ICT, rigid structure of traditional education systems, restrictive curricula, etc.

The advancement in technologies has complicated its adoption and integration by teachers in classroom. The effective integration of technology into classroom practices poses a challenge for teachers. The review has also highlighted factors that positively or negatively influence teachers' use of ICT, identified as personal, institutional and technological factors. Research has revealed that these factors are related to each other.

Knowing the extent to which the barriers affect individuals and institutions may help in taking a decision on how to tackle them. All studies have drawn a similar picture that for successful integration of ICT only infrastructure is not enough, many other factors like attitude and knowledge of teachers have to be given due importance.

Rastogi and Malhotra (2013) discussed determinants for integration of ICT in pedagogy of teachers. For the study, data was collected from private schools which employed technology usage in the teaching-learning process. The authors collected data on teachers' proficiency in ICT skills, their attitude towards technology and frequent usage of different ICT tools by them.

Of all the teachers' studied, 64% were found to be proficient in different skills related to ICT. These skills included- word processing, telecommunication, presentation, networking, teaching and learning, etc. Of all the skills studied, the teachers had less than average proficiency of the teaching-learning skills. This finding presents a challenging task as the teaching-learning skills helps in promoting an engaging environment. Further analysis showed that teachers were more proficient in general ICT skills rather than pedagogical skills of ICT usage.

The attitude of teachers towards technology was found to be favourable. This favourable attitude promotes knowledge construction and helps motivate learners. Teachers attitude towards ICT usage showed that they believed that using technology saved their time and increased their productivity while promoting learner-centred activities like collaboration among them, and cooperative learning techniques which promoted higher order thinking skills in students. The authors also divided the entire

sample of teacher in five developmental stages for ICT integration and it was found that most of the teachers were at level 2 “foundation” followed by level 1 “familiarity”. The other levels were level 3 “fusion”, level 4 “transformation” and level 5 “facilitation”. These levels represent the knowledge of teachers about different ICT tools, their confidence in selecting an appropriate tool for a specific task, incorporation of such tools in their teaching-learning process and management, solve specific problems and share their learnings with their peers. Attitude of teachers will go a long way in realising the goal of ICT integration in pedagogy.

Erdogdu and Erdogdu (2015) in their Turkey based study found that school resources and characteristics have a significant impact on student’s educational success. The usage of internet at home and school is correlated to their performance in school. The other important factors are personal characteristics, home and family background. The study also revealed that more usage of internet in school for schoolwork brought decline in students’ achievement; both home and school usage of computers and internet present important implications for their success. Authors also discussed the results of other studies carried out in this area.

Lindberg and Olofsson (2017) examined the use of ICT by students and teachers of upper secondary schools in Sweden. The study is based on interviews with 25 teachers and 39 students (in focus groups); it is a part of national research project funded by Swedish Research Council. The authors in their study found that mostly students and teachers have similar view of using ICT in their education and also, realize the potential and challenges faces while implementing use of ICT in upper secondary schools.

Teachers were found using ICT tools for purposes like recording attendance, sharing notes, communicating with students and their parents, etc. Some teachers also used specific software while teaching their subject. Overall teachers were found to be ambivalent in regards to using ICT for teaching in schools with some teachers finding its usage easy and others as difficult or unnecessary. However, it was found that teachers realized that using ICT gives them an advantage of “flexibly, in time and space”; interestingly, time is also identified by them as a challenge. While using technology enables students and teachers, the advantage of accessing information anytime and anywhere – time constraints in a class period with curriculum and subject

considerations often made it difficult for teachers to successfully use technology for teaching. Students were of similar views as teachers, but mentioned that some teachers were not competent enough to use technology and suggested that provisions in teacher's trainings would help in making them more confident while using different ICT tools. Students' out of school use of technology, especially of smartphones presented a gap between the in-school usage of ICT by both students and teachers.

Students understood the influence of ICT on their learning in general. They realized its importance in learning and how it can be a distraction in their learning as well. The authors concluded that since teachers and students had similar opinions of use of ICT in schools the major difference was in understanding the potential of use of smartphones in education by students.

Mohamed, Abubakar and Zeki (2018) studied the factors which influence ICT resources and their capabilities for higher-education institutions in Saudi Arabia. Previous researches in this area have focussed on ICT usage, policy, attitude of students and teachers, impact of ICT on learning etc. However, the present study evaluates ICT's effective utilization on the basis of information systems success theory by Delone and McLean (1992). Quantitative methodology was used in this study and authors proposed a model for judging the effective utilization of ICT. This model shows relationship of ICT resources and their capabilities to management support, training and involvement of user. The results of Confirmatory Factor Analysis show that effective utilization of ICT resources is positively correlated to management support and training. However, user involvement was not found to be associated with effective utilization of ICT. Thus the model establishes a relationship between ICT resources, management and training for effective utilization of ICT presenting implication for policy makers.

A lot of researches have been done to study the factors responsible for successful integration and use of ICT by teachers in their classrooms. The researches highlight that use of technology in education is governed by a lot of factors. It has also been concluded that these factors are inter-related and represent a complex system which requires inputs at all levels in order to observe any changes in education.

The factors have been categorised by as Manipulative/ Non Manipulative or as Internal/ External in researches reviewed. The teachers use of technology was found to be influenced by their attitude, self-confidence, skills and knowledge. The issues which greatly affect the usage of ICT tools in class are accessibility to these tools, curriculum and lack of time. School related factors like school policy for use of technology, administrative/ management support greatly impact the teachers usage. Studies have also shown that if a school provided technical support to their teachers in form of a co-ordinator, the teachers became more confident in use of technology in their classrooms.

The studies conducted earlier show that teachers were hesitant to use ICT tools in front of students because of fear of breakdown and inability to deal with such technical issues. With more focus towards using technology in classrooms, recent studies reveal that the newer teachers use technology more in classrooms as compared to their experienced counterparts. The use of technology was also found to be different across the subjects.

Both the teachers and students today realise the importance and advantages of using technology in the teaching and learning process. However, the teachers have been found using ICT tools for administrative tasks like attendance, grading, emailing etc., but the use in their pedagogy is quite behind in their list. In Indian context, Rastogi and Malhotra (2013) found that teachers, in schools which employed use of ICT in their classrooms, showed proficiency much lower in the teaching-learning activities using ICT as compared to other tasks. However, these teachers had a favourable attitude towards use of technology. This raises questions on policy and support provided to teachers to utilize the advantages of technology.

Students were also found to have positive disposition to use of ICT, however, the study conducted in Sweden (Lindberg and Olofsson, 2017) shows that students feel that their teachers are not competent enough. These students use technology more than their teachers especially smartphones. There is gap in literature which does not consider the effect of students' out of class usage of technology.

The policy changes take time to come in effect but schools can do a lot to increase use of technology. Management support will go a long way in supporting teachers to take initiatives on their own for their students. The lack in teacher training can slightly be

made up for by providing teachers support through orientations for use of technology and giving them freedom to explore and utilise ICT tools in their classroom.

EFFECT OF ICT ON HIGHER ORDER THINKING SKILLS

Gore (1991) began her paper by asking the quintessential question- why is technology being funded for in education? What role does it play? Is it to 'remediate' or to increase interaction of learners and their experience and how vital is the use of different technological aids in education.

To answer these vital question the author explored the results of HOTS program developed by Stanley Pogrow at University of Arizona. The author stressed that the role of technology i.e. computers in today's scenario wherein the greatest resource for a country is its people with great responsibility or challenge faced by the education system- is to 'unlock the potential of these minds'.

The HOTS program was developed to serve the American context wherein 'educationally at-risk students' are increasing in number. The program addressed the "concern that traditional methods for enhancing the learning potential of educationally at-risk students had failed". This program attempted to "build thinking skills" by replacing the content and remedial instruction by helping these students to use computers in a creative way. It is important that the students learn how to 'understand' and make sense of information been given to them; this 'understanding' will help them to link their previous knowledge to the present 'knowledge base'. However, the program does not advocate that the technology can be a substitute to student-teacher or other such interactions. The aim is to create such environments wherein the dialogue or conversation helps learners to "build the velcro that enables thinking".

The strategies include asking students about the information being presented and the teachers to further probe the students by asking questions, which will help in either supporting or refuting the answer given by them in the first place. One of the examples: the students use PrintShop and the teachers asks them about the word 'border'. If students are aware of the word, teacher asks students to understand the

meaning by remembering where they have encountered the word before or they build the meaning of the word on the basis of context of surrounding sentences, class or software program i.e. PrintShop in this case. Through dialogue with the teacher- the concept can be linked to other contexts as well.

The author also discusses that many would not support the role of computers being important; the most important element considered will be the "Socratic dialogue". The author refers to Pagel's' study from 1998 which explored the effect of computers on brain. Pagel concluded that computer has an effect on brain which is not fully understood.

In conclusion, author discusses Pogrow's research which suggests that this sort of a program (HOTS program) is more beneficial for at-risk students. For students who are more successful learners should spend their time in "more challenging activities". HOTS program will not help in increasing their thinking or problem- solving skills; for such students, "thinking strategies must be taught in content".

Sarapuu and Adojaan (1999) while discussing an Estonian perspective, discussed the status of educational system in their country where this case study was conducted when Educational reforms of 1997 were being implemented with consideration of integration of technology in the teaching and learning process. The authors comment,

"The learning process and teaching methods are diversified by infotechnology. It supports systematic thinking, tech-nological skills and enables students to have their own individual style of learning."

Focusing on science, authors commented that due to lack of software in Science in Estonian, teachers were not using computers in the science classroom (English being the second language), moreover, natural science is a subject which is has its own content influenced by the conditions prevailing in a country especially in case of Biology.

Based on the new Estonian curriculum, two webpages were developed 'Estonian Vertebrates' and 'Estonian Plants'. Focusing on the local Estonian flora and fauna, the webpages provided materials for various activities and these webpages were supplemented with printed worksheets.

Teachers were trained through a 'hands-on' workshop, where they used the two websites and subsequently, assessed the content, worksheets and the teaching methods. The authors used case study method, wherein the teachers used the two webpages to teach science to students. A 45 minutes lesson included an Introduction about the purpose, scope, layout and application of knowledge provided (a sheet was printed for this purpose). The rest of the lesson required students to work on their own on the tasks given in the worksheets. First unit involved going through the information and arranging in tables, second unit involved analysis, application and synthesis of the information given and finally, the third unit involved getting to conclusions and assessing the results. The second and third units clearly depict activities fostering higher order thinking skills.

Students belonged to ages of 14-15 (27 students) and 16-17 (59 students) and the pilot study showed that high percentages of students had positive outlook towards use of technology.

Hopson, Simms and Knezek (2001) discussed the effect of technology employed in classrooms, attitude of students towards computers and development of higher order thinking skills in them. For the study, Ross Test of Higher Cognitive Processes was used to test higher order thinking skills of students whereas the attitude towards computers was measured with Computer Attitude Questionnaire. The sample comprised of fifth and sixth grade students, who were divided in two groups for comparison: treatment group and comparison group. The results of the quasi-experimental study show that the treatment groups had more developed evaluation skills (as compared to other higher order thinking skills as proposed by Bloom's taxonomy, 1956) and no significant differences was found between treatment and comparison groups towards attitude towards computer and related technology. The reason can be attributed to usage of computers at home or for personal use. And lastly, technology rich classrooms have little but positive effect on developing higher order thinking skills in students. The limitation of this result can be that home use of technology as a factor was not controlled. More exposure to technology is responsible for developing favourable attitude towards and gives students to take control of their learning.

The study contributes to the limited research on the use of technology to aid development of higher-order thinking skills in students. Data provided by the study could be used to create a new paradigm for classroom structure and organization. The results will also be useful in formulation of long-range technology plans by educators. In this study, technology enabled students were encouraged to apply the knowledge instead of being limited to its mere acquisition.

Pogrow (2002) through this paper**,** aimed to bring forth the effect of and findings of the HOTS program. It describes 10 years of experience of the program. The program was initiated to help the educationally disadvantaged students, with the belief that these students are intellectually bright and a channelling of their intellect in the right direction will help them to learn 'at higher level'.

The HOTS program utilises the 'Socratic' method of teaching wherein such an environment is created in which computers are used to enhance student's interest and to help them 'test the consequences of ideas'. However, computer is not used to 'directly teach anything'.

The role of the teacher is important as the teacher has to learn to ask "systematic, creative and intensive" questions. The teacher has to talk less and initiate more active participation by students in classroom conversations. The idea is to help students to build their own thoughts, strategies and subsequently- verbalise them.

The program is designed in such a manner that students develop following-

(1) 'Metacognition'
(2) 'Inference from context'
(3) 'De-contextualisation'
(4) 'Information synthesis'

- (Pogrow, 1990)

The curriculum of school provides students with opportunities to develop these skills and to generalize them. These concepts cannot be taught exclusively, experiences of students (wherein they encounter interesting instances) help in developing the aforementioned skills as they try to use them to solve problems.

The role of computer is interesting as it is not used to present or teach or as a tool in the classrooms. Rather, the simulations provide a common platform where students can come together and discuss, solve difficulties, ideate and interpret.

The author also shared findings of the program- students who were involved in this program showed test score gains in reading, comprehension and even maths. The skills developed were transferred in over-all learning outcomes of students; as the 'understanding' skill was used across all subjects or in the way of learning.

The HOTS program helped in creating 'powerful learning environment'. Students of grade 3 were unable to respond to "open-ended thought questions" as they lacked a 'sense of understanding'. Difficulty arises as curriculum becomes more complex in middle school. For disadvantaged students the in-built content activities to teach thinking are of little use- as they lack the concept of 'understanding'. The home environment plays an important role in this context, as disadvantaged students have minimal conversation at homes and as a result are unable to discuss or have ideas. This is where it is imperative that teachers create such an environment in classrooms where conversation flows easily and students get opportunities to develop ideas and discuss them. Professional development of teachers will also be of little use as students do not understand the concept of 'understanding'. Until this is developed- professional development of staff/teachers will not be successful.

The way the interaction takes place in the classroom is what matters most. According to Pogrow, even if the development of skills is not related to content, 'understanding' skills can be developed in students by devoting some time from a school day to have meaningful interactions.

Lim and Tay (2003) conducted a case study on a government school of Singapore to study how ICT was being used to engage elementary school students for higher order thinking. The authors reviewed and listed the use of ICT tools under the following categories: "Informative Tools, Situating Tools, Constructive Tools and Communicative Tools". Usage of tools under these categories would help students to explore and analyse information presented to them. Use of simulations or mind-tools helps students to evaluate the information being given to them and helping them to reflect on it (part of HOTS).

Interviews were conducted with teachers and students were part of focus groups and classes were also observed as part of this study. The authors found that lessons involving use of ICT were mainly directed by the teacher but students participated in discussions. As per the different categories of ICT identified, it was found that different tools were used in classrooms for different purposes. e.g., a PowerPoint presentation used by the teacher to present content was also used by students to present their learning in form of a presentation for a particular assignment given to them. During class observations the authors found that the teachers were not using "Communicative Tools". However, a project from Hewlett Packard (HP) for emailing mentors was going on in school wherein a handful of students and teachers were participating.

The authors concluded that if the teacher was clear about the objective of the lesson, i.e. to teach HOTS to students, then students were found to be achieving these skills. The objective of the lesson also drove the fact that what types of ICT tool was to be used in the lesson. Students were oriented before the lesson to direct their activities in the desired direction and if students were not aware of the usage of the tool, teacher would either orient them before or during the lesson. Effective management of resources was found to be one of the reasons why ICT was being used by both students and teachers, the 'Virtual Drive Network' aided students and teachers alike to have all the material and software in one place which could be accessed easily on a computer connected to school network. Thus, how the ICT tool can be used remains the major factor for integration of ICT tools in classroom teaching and learning.

Sutherland, Armstrong, et al (2004) in their paper tried to draw conclusions from InterActive Education Project (initiated in UK) which involved University teams of researchers working with school teachers (SDTs: Subject design teams) across school subjects- English, Maths, Spanish/German, History, Science and Music. These SDTs created SDIs i.e. Subject Design Initiatives to test usage of ICT in school subject areas.

The concept of the project is based on Social cultural Theory of Vygotsky which emphasises the social learning contexts of students wherein the formal educational setting as well as the informal play an important role. Students bring their cultural experiences to the classroom, which are influenced by both outside and inside school

situations, they actively construct knowledge based on these experiences and this can be taken as an example for ICT usage. New tools of ICT need to be assessed and embedded in the existing pedagogy for different subjects to transform the teaching-learning process.

The results of the InterActive Education Project bring forth the questions about the relative roles of technological tools (digital and non-digital) in teaching-learning process. It is suggested that within a particular knowledge domain it is important for students/ young people to be able to work with these tools.

The results also indicate a positive bend towards this approach (of using ICT). Teachers also realise that ICT cannot be simply put- the whole system needs to be tailored before incorporation of technology. In instances where teachers were able to incorporate technology creatively- students performed better (esp. below average), their quality of work was better.

In cases where students can utilise technology better than their teachers, was a cause of low-confidence in teachers. Data collected through questionnaires reveal that teachers are 'unaware of the nature and extent of student's expertise in using technology outside school.

What the paper brings out is the perspective which strongly supports the 'diversity of student experience' into any 'learning situation'. This might pose problems for teachers but 'creative teachers' were able to make a difference and created better classroom instruction practices involving technology. "ICTs are a part of creative production" of humans. It opens new avenues for students as well as teachers who can incorporate these tools to enhance the teaching-learning experience.

Eng (2005) in his paper tried to study the impact of ICT on learning; the findings tried to evaluate its effectiveness on student's learning outcomes. The studies encompassed U.S., U.K. and Australia. The research was divided in periods of 1960s-1980s, which saw usage of ICT for specific purposes and the impact was measured using experimental methods and 1990s-2000s which focussed on use of ICT across the entire educational environment. The findings suggest that American schools show a positive trend in achievement of students, when ICT is being used; also it was found that teacher's tailor made programs are more effective than the commercial programs

available. The students understanding of ICT is more advanced due to usage of ICT in outside the school context. The evidence of the findings present in this study also reveals some areas which require further research.

The findings suggest that there is a small but positive effect on learning of students. Most researches are optimistic about roles of ICT in education while some have reservations. More research is required to know the ground realities instead of having false expectations.

The paper in conclusion draws an analogy between ICT integration and invasion of an ecosystem. More time will be required by teachers, students and principals to adjust to the new environment and then only we shall be able to draw benefits from ICT. The schools will have to pass the phases of emerging, applying and transformation (UNESCO, 2002).

Law, Lee, Chan and Yuen (2008) in their paper presented at the Third IEA International Research Conference in Taipei discuss ICT and its effect on student's learning. They discussed the factors which influence ICT, through data obtained by SITES 2006 project. The teacher survey in SITES 2006 was designed to provide a variety of indicators related to pedagogy and ICT, including: (1) teachers' perceived impacts of ICT-use on their students, (2) teachers pedagogical orientations for their overall practices as well as for their ICT-using practices, and (3) teachers' self-reported technical and pedagogical competence in using ICT for teaching and learning. Multilevel analysis revealed that the general pedagogical orientation of the teacher has a much stronger relationship with the perceived impact of ICT-use on students' learning compared to the more specifically ICT-related pedagogical orientations. Further, the self-perceived pedagogical ICT-use competence of the teacher was an even stronger predictor for the perceived impact of ICT-use on students.

Many countries have placed emphasis on promoting the use of ICT in teaching and learning, which can be observed by the number of programs and initiatives being taken all across the globe. These reforms are not limited to availability of infrastructure but often in combination with curriculum reform initiatives that aim to develop the development of 21st century skills such as collaborative inquiry and collaboration.

McMahon (2009) examined the relationship between students working in a technology-rich environment and their development of higher order thinking skills, through this paper based on a thesis. Staff and students from one school formed the sample in the study. Data was collected to determine the degree of correlation between factors affecting the learning environment and the extent to which critical thinking skills were demonstrated by the students. Statistical correlations were made to observe relationships between environmental factors and critical thinking. The results indicate that there are statistically significant correlations between studying within a technology-rich learning environment and the development of students' critical thinking skills. The time spent in the technologically supported environment has a positive effect on the development of critical thinking skills. Students with better developed computing skills scored higher on critical thinking activities.

Teaching specific skills related to computer programming was found to enhance students' attainment of higher order thinking skills. The programming skills included developing an understanding of Boolean logic, top-down approaches to solving problems and exploring data manipulation from novel dimensions. The development of computer skills within a socially constructivist, technology-rich environment allowed students to attain higher order thinking skills. Schools should endeavour to integrate technology across all of the learning areas. This will allow students to apply technology to the attainment of higher levels of cognition within specific contexts. If students are to apply computer based technology to their studies they must be given the opportunity to develop appropriate computer skills. The power of computers in education lies in embedding them in the curriculum and not using them as add-on tools.

Finch (2012) in the impact report published for Learning Support and Technology Unit of Manitoba Education and training (Department of Government of Manitoba, Canada) gave an outlook of how the literature in ICT in education reflected the changes in the field over the past years. Focusing on a relevant view that the development of technology over the past few years is not similar to the development in the field of education, it dealt with the questions of impact of ICT on learning and achievement of students and its role in their engagement. The review and analysis of meta-analysis of ICT's impact on learning and achievement brings to light the fact that impact of ICT is difficult to measure. Achievement in learning through ICT can

be directly linked to it, as learning is a result of the whole environment and ICT is just a part of that environment. It also shows that the impact of ICT is more when it is used as part of teacher's pedagogical repertoire i.e. when used with a student-centred approach, ICT's effect is more pronounced.

In terms of developing skills like critical thinking and HOTS, research shows that ICT is a positive influence in acquiring these skills when the technology based tasks are given to students that require them to explore and evaluate the available information. The review also quotes Balanskat (2006) who in his paper discusses that HOTS, team working skills, etc. are affected through ICT even though they are not recognized.

While discussing the impact of ICT on students' engagement and motivation, the review highlights several factors responsible for it. Usage of ICT by students and teachers both at home and school is an important motivator for them. Similarly, location of tools in classroom like allowing students to bring in their own devices enables more effective use as compared to the situation wherein the computers are available in separate labs.

Otero, Petch and Catapan (2012) tried to analyze how distance education courses which use e-learning help in enhancement/development of higher order thinking skills, through an exploratory study (using interviews). Distance education courses are crucial for education the masses and for economies. These courses aim to increase employability of students by autonomous learning which leads to development of higher order thinking skills. The autonomy of distance education courses is its main characteristic as the focus is on the student and the independence of their learning. The thinking skills are generally referred to as: reflective skill (developed as a result of inference of relationship between various elements of experience), critical thinking skill (involves looking for a reason for what is being done) and problem solving skill (involves taking steps to solve problem at hand). E-learning helps in fostering reflective skill as it demands active participation of student in the learning process, students get to collaborate when working in online environment which increases their sociability. Autonomous study helps in critical evaluation of the material presented for study and also enhances problem solving skills. Students are motivated to learn when they know what they are learning and why they must learn it and how should they study. However, the assessment of higher order thinking skills becomes difficult

but tracking of activities of students is easier. Asynchronous interactions of students where the onus of learning lies in the hands of the students will be helpful in developing higher order thinking skills in students.

The paper has identified higher order thinking skills, apart from Bloom's taxonomy. According to it, at the cognitive level 6 skills are: Knowledge, Comprehension, Analysis, Application, Synthesis and Evaluation. Out of which application, synthesis and evaluation are higher order thinking skills. The skills discussed in the present paper can be more aptly considered 21st century thinking skills; considering the purview of the paper is e-learning, the skills discussed find more relevance in today's world.

Al-Hawamleh and Al Jamal (2013) through their paper, tried to fill in gap of researches to study the influence of computers and computer mediated instruction on cognitive skills. The scope of research was development of 3 cognitive skills of Knowledge, Comprehension and Application (based on Bloom's taxonomy).

The research is based on experimental design- limited to 10^{th} class students of Jordan, studying English. The research aimed to help in adding information about impact of computers in order to help decision makers in field of education – make an educated decision about the investment in the resources.

Methodology involved dividing the sample in 2 groups; the experimental group was taught English by using computer and the control group was taught using traditional methods wherein the same teacher taught both the groups. Hypothesis was framed for achievement of 10^{th} class students on levels of knowledge, comprehension and application. The achievement test adopted was by Al-Jamal and Obiadat (2008), the test was modified by researchers to test students on levels of knowledge, comprehension and application (based on Bloom's taxonomy).

After the post-test was conducted, the results were presented on the basis of hypothesis framed for the study. Findings of the study show that there is :

(a) No difference in achievement of students (at experimental and the control group levels) at level of Knowledge i.e. both traditional method and using computers to teach English have similar effects

(b) In case of level of achievement at comprehension level and application level, the hypothesis framed was rejected i.e. there was a level of difference of achievement reported for experimental and control groups.

Presentation of material through computers along with traditional method helped students in perceiving the facts better (Kung, 2004; Singhal, 1997 as cited in Al-Hawamleh and Al Jamal, 2013). Computers helped in creating an 'attractive setting'. Since, the students were using a virtual workroom to communicate- which encouraged them to participate more willingly. Use of different images, colours and sounds helped in their mental stimulation. Moreover, students of experimental group had more positive attitudes and were confident in using computers- as it was a new experience to use computer as an 'instructional device'.

Students of experimental group were also able to go back to sections of material which were difficult for them in the first place and immediate responses to their wrong answers helped experimental group to try again. However, all the students of control group did not have this opportunity. Collaborative learning and opportunity for all types of learners added an extra advantage to the experimental group.

In conclusion, researchers recommend that there should be continuous collaboration between software designers and schools to increase the use of technology in classrooms, using tailor-made software based on teaching contexts. Involvement of computers in education makes learners feel that they are in control of the whole learning process. Belisle (1996) also suggested that using computers help students in becoming better problem solvers and communicators.

Prakash (2013) conducted a study to examine the relationship between student performance and ICT. The author states that the factors: characteristics of students, the educational environment and teacher's characteristic may be influenced by ICT. An experimental study was carried out wherein a multimedia package was developed on a topic from class X science textbook. The package included a Microsoft Presentation having text and images. A pre and post-test method was used to ascertain the impact of ICT, t-test was carried out, the results were significant at 0.01 level which emphasised the effectiveness of the package. The author concluded that ICT has an impact on student achievement and performance and its use can change the environment of the classroom. It can also help in promoting student centred approach

of instruction which would eventually lead to develop “reflective and higher order thinking”.

Abrami et al (2015) studied how different instructional strategies helped in development and enhancement of critical thinking skills and student dispositions and achievements. About 341 studies employing quasi or true experimental studies which used critical thinking as an outcome were studied. After discussing different theoretical aspects of critical thinking the authors used Facione’s interpretation of critical thinking (1990) in which he has explained it as “Purposeful, Self-Regulatory judgement which results in Interpretation, Analysis, Evaluation and Inference…”. Authors also listed skills and subskills of critical thinking. The meta-analysis eventually led to identification of four categories and a rating scale (of 0-3) was used to identify its presence in a study. The four categories were Individual Studies, Dialogue, Authentic/Anchoring Instruction and Mentoring. The analysis concluded that a variety of critical thinking skills can be developed in students through different instructional strategies across all levels and discipline e.g., simulation (aided by use of ICT) and playing games with more hypothetical situations can be used to hone these skills. It was also found that when more opportunities are given for discussion, i.e. teachers ask questions, there is a whole class or teacher-led discussion. These skills are also promoted when students are presented with authentic issues of situated problems. However, it was concluded that mentoring alone (for these skills) would not develop any strong results unless it was combined with another powerful strategy.

Budsankom et al (2015) reviewed literature available on factors affecting HOTS and identified class room environment, family and psychological characteristics and intelligence as the factors which affect each other. The authors used meta-analysis structural equation modelling approach (MASEM) to analyze the studies conducted during the period 1999-2013 available online in higher education institutions of Thailand. The studies having at least two factors related to HOTS and sample as government school students. The analysis showed that psychological characteristics had a higher effect size than classroom environment; this effect size was double in case of intellectual characteristics for HOTS. However, family characteristics did not affect HOTS significantly.

The intellectual characteristics identified for the study were IQ and reasoning abilities. Family characteristics included parenting style and support. Classroom environment characteristics included climate of the classroom, teaching - learning methodology and behaviour of teacher. And the psychological characteristics identified were attitude toward learning, motivation in students for achievement and students focus for achieving their goals.

The classroom environment was found to be affecting psychological characteristics of students and family characteristics, similarly. HOTS were found to be indirectly influenced by family characteristics (directly influenced by psychological characteristics) and classroom environment (also influenced by psychological characteristics and intellectual characteristics). Another finding suggested that family characteristics influence intellectual characteristics of students but did not enhance HOTS of students. The study presents systematic analysis of factors which affect HOTS and, suggested measures which can be easily implemented in classroom for inculcating HOTS in students.

Chandra and Mills (2015**)** discussed the results of technology rich classrooms (TRC) program in an Australian high school for which 10 school teaches had volunteered. The authors listed the prerequisites for TRC learning environment; for successful implementation of such a program the while schools should work towards enabling all stakeholders to participate in the process for ICT integration. Since, teachers who participated in the project had volunteered, it ensured that they were self-motivated, competent and had positive disposition towards use of technology. This team of teachers was also asked to identify the objectives which were to be achieved through the program; the teachers were successful in planning ICT driven activities, and incorporated them in the existing time tables.

For achieving success in the project, resources were made available and strict guidelines for usage of computers and authorised access to teachers on school network enabled in planning, monitoring and controlling student activities. Data was collected through observations and interviews for two years. The teacher, after the end of two-year period, wanted to remain in the program; the reasons reported were that their students were motivated and doing well in classes. Teachers also mentioned that their pedagogical and ICT skills were improving. The school leadership and

community had also realised the importance of ICT for 21st century learning. Consequently, teachers could discuss their requirements, and suggest hardware and software to be used by them. This led to teachers having a sense of ownership for their classrooms as well as the program. Teachers were also free to use different technological tools of their own accord which helped them to adopt tools as per their choice and make progress at their own pace. Teachers were observed using different tools for simulation in science, self-paced learning software for Maths and in other subjects. Using these tools ensured that activities being planned were learner-cantered and more engaging for students.

The project at the end of two years showed that schools had shifted from traditional to transformative paradigms. However, the authors believed that more time was needed to observe this transformation clearly. When schools visualise how technology can offer possibilities for teaching-learning process, then a paradigm shift is bound to happen.

Jahanian and Rajabi (2016) compared critical thinking for girl students in ordinary and smart schools of a district in Iran. They emphasised that teachers must promote thinking and reasoning skills of students as they are not limited to the class, but should be partnered with them for their lives. The features of education for 21st century requires students to be innovative, and requires teachers to use different teaching method, promote collaboration, focus relevant contexts for teaching and learning and use of different ICT tools. The authors also quote different studies to emphasise importance of technology for inculcating critical thinking.

For data collection, California Critical Thinking Test was used to measure “analysis, inference, evaluation, inductive and deductive reasoning”. The results showed that there was difference between scores in ordinary and smart schools - which smart schools scoring more than ordinary schools overall. While measuring the snub-skills it was found that students from smart schools performed better in skills of inference, inductive and deductive reasoning. On the other hand, ordinary schools were better on analysis and evaluation skills. The authors concluded that class environment may encourage students to discuss and think, which inculcates thinking skills in students. The comparison of ordinary and smart schools for critical thinking shows that the

better score on sub skills can be attributed to a lot of factors – such as the learner, class environment, and the teacher.

The studies which ascertain the effect of ICT usage on development of higher order thinking skills are either reports of the programs, experimental studies or meta-analysis of researches done. The studies reviewed highlight an important fact about assessing effect of ICT on HOTS i.e. this impact is difficult to measure as achievement in a technologically rich environment is a result of the environment, of which ICT is only a part. It was also deduced that ICT in isolation will not affect learning until it is paired with another strategy. The review elucidates how use of ICT in a classroom aims to create a learning environment wherein the longer the exposure of the students, the better their higher order skills are. The purpose is not replace or undermine the teachers but to encourage them to create content which inculcates such skills in students.

The students bring their own experiences to the class, from their home environment along with their psychological characteristics that influence their higher order thinking skills. The experimental studies conducted show that ICT use has a small but positive impact on higher order thinking skills of students. In terms of Bloom's taxonomy, the students evaluation skills were more affected by use of technology than others.

Teachers awareness of the objective of the lesson to teach HOTS ensures that such objectives are realised. Using different strategies in their pedagogy, such as discussion, simulations, games, etc. teachers can engage students in interaction with them; such interactions help teachers to guide students to their objectives. General awareness of pedagogy of teachers was found to be more effective to teach HOTS to students rather that pedagogy involved with ICT. Effective management also plays an important role in motivating teachers; curricular reforms and school support encourage teachers to devise strategies to teach HOTS through their content. Pogrow (2002) in his study mentions that higher order thinking skills are transferable, which presents an important implications for our learners today.

The review conducted for the study strengthens the rationale for the present study. A gap was found in literature wherein studies assessing the effect on ICT on higher order thinking skills in Indian scenario were lacking. Recently studies conducted in the country on such skills were conducted on engineering students. The studies which show that ICT has impacted higher order thinking skills of students either give mixed results or program specific outcomes. The relationship between the variables governing this process is so complex that no direct relationship can be derived between them. Also, when an experimental study is conducted it is difficult to control all variables which affect this phenomenon and thus, the results from the studies reviewed help in identifying the factors which influence use of ICT and development of higher order thinking skills.