Chapter II

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THEORETICAL OVERVIEW

Recent advances in Science and Technology have changed the structure and the educational systems of societies. The increasing importance of skilled person not only to use knowledge but to be a producer of knowledge puts additional responsibilities on the present day educators of science. Education is expected to be a purposeful and enjoyable activity. The knowledge and experience gained through schools, the methods and materials used for imparting knowledge of facts, concepts, principles, generalizations, etc must be interesting and related to real life situations. The way in which knowledge is imparted will encourage and help the child to think, feel and act for himself from the very early years of life. The three simple and basic goals of education are retention, understanding and active use of knowledge and skills. Retaining and understanding knowledge and skills is worthless unless the learner actually makes active use of them later in life.

The challenges of retention, understanding and active use of knowledge and skills confront education and educators of the present on a massive scale, accompanied by the problems of at-risk learners, the low funding of education, an aging population of teachers less familiar with new technologies and so on. Amidst these troublesome aspects, however some positive signs can be observed. Two of these are ‘information processing technologies’ and the diversity of educational practices surrounding the idea of ‘constructivism’.
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National calls for improving Science Education suggest changes in science classrooms that include using technology, situating instruction in a context, facilitating learners to share ideas and information and encouraging students to explore questions in order to develop in-depth understanding of science content and processes. One approach for accomplishing these goals is to change classroom settings so that learning is more collaborative, thereby helping students to engage more thoughtfully in activities as they work with peers.

This chapter focuses on the theoretical background of Computer-Assisted Instruction, Constructivism and Constructivist-Computer Assisted Instruction, which are the three methods employed in this study. The chapter also gives an overview of the Revised Bloom’s Taxonomy for Cognitive Domain, which the investigator has used for the study.

2.1 COMPUTER ASSISTED INSTRUCTION

Computer Assisted Instruction (CAI) is among the range of strategies being used to improve student achievement in school subjects. It is believed that they reflect what good teachers do in the classroom. Computer programs are interactive and can illustrate a concept through attractive animation, sound and demonstration. They allow students to progress at their own pace and work individually or solve problems in a group. Computers provide immediate feedback, letting students know whether their answer is correct. If the answer is not correct, the program shows students how to
correctly answer the question. Computers offer a different type of activity and a change of pace from teacher-led instruction.

2.1.1 Definition of Computer Assisted Instruction

The Association for Educational Communications and Technology (1977) has defined Computer-Assisted Instruction (CAI) as a method of instruction in which the computer is used to instruct the student and where the computer contains the instruction which is designed to teach, guide, and test the student until a desired level of proficiency is attained.

Computer-Assisted Instruction is defined by Frenzel (1980) as the process by which written and visual information are presented in a logical sequence to a learner through a computer. The student learns by reading the text material presented or by observing the graphic information displayed. Some of the programs provide audio-visual presentations with an option to the student to select audio presentation in addition to the visual media. Each segment of the text is followed by questions, for student’s response. Feedback on response is indicated immediately (Wang & Sleeman, 1993).

Locatis and Atkinson (1984) describe Computer-Assisted Instruction as a mode of instruction that involves student interaction with the computer directly. Typically, students access program presented in segments, with each segment including information and questions or problems for student’s response. The correctness of each response is indicated immediately and remedial or new information is presented. As CAI usually involves a dialogue between one student and a computer programme and as the student
can learn at his own pace and time frame, it is called interactive and individualized learning (Curtis & Howard, 1990)\(^5\).

Chauhan (1994)\(^6\) describes CAI system in terms of its hardware (the machine), its software (the programme), its communication links (the devices which allow learners to use the hardware and software), and the curriculum (teaching material stored in the computer). With the advancements in technology, new dimensions of CAI have emerged. Bucholtz (1999)\(^7\) adds new meaning to CAI by using the term for internet based instruction through the use of web pages, web bulletin boards and real audio, graphics and hands-on applications.

2.1.2 History of Computers

The history of computers is rooted in man’s search to find easier means of calculation. A list of the calculating machines that were invented is focused below.

The earliest calculating machine was the abacus, which appears to have its origin in Pheonicia in the form of a sand-covered stone, called an abak. According to the Association for Educational Communications and Technology (1977)\(^1\), “The abacus is a device, usually of wood or plastic, having a frame that holds rods with freely-sliding beads mounted on them.”

**FIGURE 2.1**
Abacus
In 1616, John Napier made a calculating device, called **Napier’s Bones** for addition, subtraction, multiplication and division of numbers.

![FIGURE 2.2](image1)

**FIGURE 2.2**
Napier’s Bones

In 1642, Blaise Pascal designed and built the “**Pascaline**”, the first mechanical calculator, which comprised of sets of interlocking cogs and wheels.

![FIGURE 2.3](image2)

**FIGURE 2.3**
Pascaline

Gottfried Wilhelm Leibniz improved upon Pascal’s device and in 1671, he invented the “**Leibniz Wheel**” to perform multiplication, division and to find square roots.

![FIGURE 2.4](image3)

**FIGURE 2.4**
Leibniz Wheel
In the 19th century, Charles Babbage invented the Difference Engine, to prepare mathematical tables.

**FIGURE 2.5**
Difference Engine

Babbage also designed the Analytical Engine; which can be called the prototype of the computer because it had the same basic elements as the modern computers, namely, input, output and memory devices.

**FIGURE 2.6**
Analytical Engine

The next major advance came in 1890 with the invention of the Hollerith Machine by Herman Hollerith, which was used to tally the census figures. After the success in the 1890 census, Hollerith founded the Tabulating Machine Company, which later merged with other companies to become the International Business Machines Corporation (IBM).
Just before World War II, the first electronic computer called **Mark-I** was developed by Howard Aiken. Mark I used electromagnetic relays that would click open and close. The sound it made was reminiscent of a room full of people knitting. It was over 50 feet long and 8 feet tall and had one million parts and 500 miles of wire.

**ENIAC: the first modern computer**

ENIAC (Electronic Numerical Integrator and Calculator) was the first fully electronic digital computer developed by John Mauchly and Presper Eckert based on the ideas of John Atanasoff.
2.1.3 Evolution of Computers

The limitations of the ENIAC became obvious very quickly, particularly the fact that to change its function required rewiring a substantial part of the machine, which was a slow process. The solution to this problem is usually attributed to John von Neumann who came up with the “stored-programme” concept, in which the sequence of instructions to be performed called a *program* could be entered in much the same way as data stored in the computer to be stored when needed. Being able to do this made rewiring the computer each time unnecessary.

**EDSAC, EDVAC & UNIVAC**

The first machine using this concept was the *EDSAC* (Electronic Delayed Storage Automatic Computer), which was built at Cambridge University in England in 1949. At the same time, Mauchly and Eckert, the original builders of the ENIAC, continued their efforts and produced their own stored-programme computer, the *EDVAC*, in 1952. Shortly thereafter,
they developed the first commercially available electronic computer, UNIVAC 1 (Universal Automatic Computer I)

First-generation computers (1951-1959)

The UNIVAC I was the first of what have come to be called first-generation machines. These used vacuum tubes and were large in size, performed slowly, and programming capability was quite low.

Second-generation computers (1959-1964)

The era of second-generation computers started in 1959 with the replacement of vacuum tubes by transistors thereby increasing their reliability and computational speed, and reducing their volume, cost, and power consumption.

Third-generation computers (1964-1971)

Third-generation computers used integrated circuit or IC which allowed many components to exist on a single small chip. ICs were even more reliable than transistors, were cheap to produce, were compact, and used virtually no power at all compared to previous technologies. One
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of the most important products developed from the integrated technology was
the microprocessor.

**Fourth-generation computers (1971 - present)**

Once the integrated circuit became a reality, the story of further
developments centered around how many circuits could be packed on a single
silicon chip. Large-scale integration (LSI) made possible the pocket calculator
and the digital watch. Advances in microprocessor technology were paralleled
by the development of memory chips. The microprocessor would direct
information to be stored in these chips, as well as to be drawn from the chips
in the course of executing the programs.

**Fifth-generation computers (Present)**

Fifth generation computing devices, based on artificial
intelligence, are still in development, though there are some applications, such
as voice recognition, that are being used today. The use of parallel processing
and superconductors is helping to make artificial intelligence a reality.
Quantum computation and molecular and nanotechnology will radically
change the face of computers in the years to come. The goal of fifth
generation computing is to develop devices that respond to natural language
input and are capable of learning and self-organization.

**2.1.4 History of Computers in Education**

The first use of computers by educational institutions coincided
approximately with the introduction of second-generation computers at the
end of the 1950s. About that time, large universities began using computers
for administrative purposes such as accounting, payroll, and student record keeping. At the same time people began using computers for instructional research.

One such research application was the **PLATO** project at the University of Illinois, which began in 1960 with the goal of designing a large computer-based system for instruction. Soon after, IBM introduced **Coursewriter**, a programming language designed for preparing instructional materials on IBM’s large computers. The PLATO project further developed into PLATO IV, a large time-shared instructional system. With PLATO IV, students studied on individual terminals, hundreds of which were connected to a large computer on which all lessons and student data were stored. All program execution occurred on the main computer, which communicated with the terminals by telephone line. The PLATO expanded from a classroom of about twenty student workstations to over a thousand student terminals throughout the country.

In 1972, The MITRE Corporation and Brigham Young University started development of the **TICCIT** (Time-shared Interactive Computer Controlled Instructional Television) system. With TICCIT, students studied lessons presented on standard colour televisions and interacted through modified typewriter keyboards, all of which are controlled by a minicomputer. Lessons on TICCIT always included a variety of information presentations, examples, practice problems, tests, and a “map” of the structure of the curriculum. The keyboard had, in addition to the
ordinary alphanumeric keys, special keys labeled RULE, EXAMPLE, PRACTICE, EASY, HARD, and ADVICE. By pressing these keys the student could change instructional activities, ask for easier or harder activities, or ask advice as to what to do. Learner-Controlled Instruction had two intended advantages. First, students could adapt the sequence of instruction to their own pace and learning styles. Second, instructional developers did not have to make complex decisions about content sequence, because the students made their own sequencing decisions via keyboard. Both the PLATO system and TICCIT became commercially available during the 1970s.

Seymour Papert at the Massachusetts Institute of Technology began research on teaching children by having them programme computers. Papert, following the educational theory of Jean Piaget, maintained that students could learn many problem-solving skills on their own, given the correct educational environment, which he claimed to be an easily programmed computer. Two major developments of Papert’s projects were LOGO, a powerful but easily learned programming language, and the turtle, a small robot that children could control using LOGO.

With the introduction of three microcomputers, TRS-80, PET and Apple, in 1977, it became possible for the individual university researcher, the small public school, and even the individual public-school teacher to buy one and to start using it for educational purposes.
Taylor (1980) classifies the use of computers in education under the following categories:

a) as a tutor

b) as a tutee

c) as a tool.

**Computer as a tutor:** The computer can be used to teach the learner through tutorials, drill and practice, games, simulations or a combination of these strategies.

**Computer as a tutee:** The learner assumes the role of a teacher and the computer becomes the tutee. In other words, the learner programmes the computer by communicating with the computer in a language which both can understand.

**Computer as a tool:** Computer acts as a tool in extending our mental capabilities. Computers can never replace teachers but can be used as an aid in the teaching-learning process.

### 2.1.5 Programmed Instruction

Programmed Instruction is basically a 20th century phenomenon. Significant contributions were made by Sidney L. Pressey as early as 1915 in his efforts at the Ohio State University to build a simple machine for testing comprehension of material that had been taught. These crude machines presented multiple-choice questions to users while providing immediate knowledge of their results. These early teaching machines also known as Drum Tutors represent what Pressey called adjunct auto-instruction (Pressey,
These machines were not integrated into the instructional material; rather, they were adjunct to traditional instruction usually the text, much the same as adjunct questions.

**2.1.5.1 Skinner’s Extrinsic Programming**

Modern PI is normally associated with B. F. Skinner. His involvement is usually traced to his famous 1954 professional address, “The Science of Learning and the Art of Learning” in which he described the traditional classroom instruction as being too aversive, too large, too negative, and improperly sequenced. His solution to these problems was linear programmed instruction. Unlike Pressey’s “adjunct” programming, designed to supplement regular course study, Skinner’s linear teaching programmes were designed to replace traditional courses of study and to function as an instructor for users with no prior knowledge of a subject. Skinner’s PI required the “user to construct an answer by filling in a blank with the correct response, instead of selecting one of four options as correct, as in Pressey’s machine. Filling in a blank is a recall type of learning as the user has to recall the answer from memory rather than merely recognizing it as in multiple choices. After filling in the blank, the user compares his or her answer with the correct one.” (Skinner, 1954).

**2.1.5.2 Crowder’s Intrinsic Programming**

Norman A. Crowder, a contemporary of Skinner, was working independently for the armed services on programmed instruction. He felt that a programme was a form of communication between a programmer and a user...
and that like any communication; the programme must be directed to the user. Unlike Skinner, Crowder was not working from a psychological perspective, but from a communication point of view. In an intrinsic or branching programme, each frame presents more text than the average linear frame. After reading, the user responds to an adjunct question, usually in a multiple-option format. The branching style optional choices lead users to optional forms of feedback, most of which is corrective. If the user makes a correct response, the programme asserts the reasons why he was correct and moves on to the new material. If an incorrect response is made, the programme, at the very least, informs the user that an error was made and then branches the user back to the previous frame for another try.

The primary purpose of feedback is to determine whether the communication was successful, in order that corrective steps be taken (Crowder, 1960). Depending upon the complexity of the error committed, the programme may initiate a remedial sequence of instruction. Branching instruction adapts the sequence of the programme to a limited degree to fit the prior learning and processing capabilities of the user. The term intrinsic refers to the fact that all programme options are intrinsic to the program and, therefore, not dependent on any external programming device. This type of programming benefits the higher-ability user, who is more capable of higher-level integration of ideas, more than it does the lower-ability user.
2.1.5.3 Decline of Programmed Instruction

The popularity of PI reached its zenith in the mid 1960’s but declined steadily through the 1970's. With PI no longer perceived as a panacea, the educators began to rely more on instructional systems development processes, including statements of objectives, task analysis, evaluation, and revision. The process of creating programs was being applied to alternative media, such as slides, filmstrips, and instructional television. Various methods for sequencing PI were being investigated. PI was just turning into a true technology as it began to fade from prominence.

In the late 1960’s, a corpus of research became available which indicated that Programmed Instruction was the most effective as a supplement to normal instruction. It surely represents one of the greatest bandwagons in the history of education. By the mid 1960’s, instructional programs were available on virtually every topic taught in schools. Hundreds of articles were written and published every year which either examined or extolled the virtues of PI. But, PI was clearly on the down slope of its developmental cycle.

2.1.6 Rise of Computer Assisted Instruction

Concurrent to PI’s decline, the newest bandwagon in education, Computer-Assisted Instruction, was gathering steam. Even though PI and CAI were developing independently in the 1960’s, the instructional sequences and techniques of PI were borrowed by CAI. The key concepts of programmed
instruction such as the tutorials, management, general enrichment, drill and practice, programming, and simulation programs are all present in CAI also.

Some of the first computer-assisted instruction (CAI), developed by Patrick Suppes at Stanford University during the 1960s, set standards for subsequent instructional software. After systematically analyzing courses in arithmetic and other subjects, Suppes designed highly structured computer systems featuring learner feedback, lesson branching, and student record keeping. According to Cronbach et al. (1977), during the 1970s, a particularly widespread and influential source of computer-assisted instruction was the University of Illinois PLATO system. This system included hundreds of tutorial and drill and practice programmes. Like other systems of the time, PLATO’s resources were available through timesharing on a mainframe computer.

Its continued development has been fueled by the explosion of microcomputers in the 1980’s and 1990’s. The visual and auditory embellishments afforded by the graphics and sound capabilities of microcomputers make the reinforcement of drill and practice programmes initially more desirable, and the programmes are able to keep records on a user’s performance, but its fundamental instructional model is that of PI.

Today, microcomputers are powerful enough to act as file servers, and CAI can be delivered either through an integrated learning system or as stand-alone software. Typical CAI software provides text and multiple-choice questions or problems to students, offers immediate feedback,
notes incorrect responses, summarizes students’ performance, and generates exercises for worksheets and tests. CAI typically presents tasks for which there is only one correct answer; it can evaluate simple numeric or very simple alphabetic responses, but it cannot evaluate complex student responses. A more advanced form of CAI is the Integrated Learning Systems. ILSs are networked CAI systems that manage individualized instruction in core curriculum areas such as mathematics, science, language arts, reading, writing and so on.

2.1.7 Different Types of CAI

Among the many CAI available in market, six specific types by Spiro and Jehng (1990) seem to be most often utilized for educational purposes.

**Drill and practice:**

*Drill and Practice* instructional programmes simply assist the student in remembering and utilizing information that the teacher has already presented, reinforcing previous learning through repetition. It is most important to improving knowledge level.

**Tutorial:**

*Tutorials* are designed to introduce unfamiliar subject matter. The format of a computer tutorial often emulates a dialogue between the computer and the student, that is, information is presented, questions are asked to the student and on the basis of the response given, a decision is made to move on to new material or review what has already been presented.
Tutorials are most successful at improving the knowledge and comprehension levels of Bloom’s taxonomy.

**Instructional Games:**

*Instructional Games* present course content in a competitive and entertaining manner, in an effort to provide intellectual challenge, stimulate curiosity and motivate the individual learners so as to maintain a high level of student interest. Though most frequently used to reinforce factual knowledge at the lower levels of the taxonomy, it is quite possible to create instructional games that demand *application skills* from all levels.

**Simulation:**

*Simulations* require the student to apply acquired knowledge to a novel situation. As a result, the student must analyse a presented scenario, make decisions based on the information given and determine a course of action. The simulated environment must change based on the course of action taken, presenting a significant challenge to the programmer. Successful performance relies on skills up to Bloom’s level of *analysis*.

**Discovery Environment:**

Discovery software provides a large database of information specific to a course or content area and challenges the learner to *analyze, compare, infer and evaluate*, based on their explorations of the data.
Problem Solving:

Problem solving software teaches specific problem solving skills and strategies. One of the best known problem solving instructional material packages is Logo.

Thus, with the use of computers in the classroom, the teacher maintains control over the instructional process. Computers and the content they access are simply raw materials that the teachers can use to make sense of particular classroom contexts. Computer technology increasingly promotes interactivity in contrast to the passive approaches of film, radio and television. Interactivity plays additional control and choice in the hands of teachers and students.

2.1.8 Advantages of CAI

♦ It allows normal and even unusual errors that people are apt to make.
♦ Any user can work independently at the console.
♦ The programmes respect the individuality of the students by allowing them to make frequent choices with many options.
♦ The feedback to the users helps enhance their motivation.
♦ CAI material presents the learner with a novelty. They teach the subject in different and more interesting, attractive ways and present topics through games and problem solving techniques.
♦ Computers offer a valuable source of self-access study adaptable to the learner's level.
Students are more relaxed, they are no longer afraid of being corrected, judged or watched.

Computers have no ‘days off’.

Computer will tirelessly go over and over again the same point for as long as necessary.

Computer can provide the information requested in a very short time.

2.1.9 Limitations of CAI

Learners who do not have prior experience in using a keyboard might waste time identifying letters on the keyboard.

Working with computers does not help in developing normal communication.

The time and effort needed to develop such programmes can be considerable.

Computers cannot cope with the unexpected.

2.2 CONSTRUCTIVISM

As we watch a small child grow from infancy to toddler hood, we will be very much surprised at the vast amount of learning that has allowed him to understand his expanding environment. These early years provide the basis for language, physical dexterity, social understanding, and emotional development that he will use for the rest of his life. The child taught himself by gathering information and experiencing the world around him. Such learning exemplifies constructivism.
Constructivism emphasizes the importance of the knowledge, beliefs, and skills an individual brings to the experience of learning. It recognizes the construction of new understanding as a combination of prior learning, new information, and readiness to learn. Individuals make choices about what new ideas to accept and how to fit them into their established views of the world. Constructivism is first and foremost a philosophy of knowing. As such, it has been adopted by educators as a way of thinking about teaching and learning.

2.2.1 Constructivism – Definition

Constructivism is an approach to teaching and learning based on the premise that learning or cognition is the result of “mental construction”. In other words, students learn by fitting new information together with what they already know. Ernst von Glasersfeld (1987)\(^{14}\) breaks down constructivism into two basic principles. The first is that, “knowledge is not passively received either through the senses or by way of communication, but is actively built up by the cognizing subject”. The second is that, “the function of cognition is adaptive and serves the subject’s organization of the experiential world, not the discovery of an objective ontological reality”. Thus, students learn by doing, not by being merely receptors of knowledge or information. When students construct meaning, they do so as active participants in the acquisition of knowledge. They need to assimilate information so that they can make it fit into a scheme of knowledge they already have. As Glasersfeld (1995)\(^{15}\) puts it, “Knowledge is always the result
of a constructive activity and therefore cannot be transferred to a passive receiver.”

Constructivism is a view of learning based on the belief that knowledge is not a thing that can be simply given by the teacher at the front of the room to students in their desks. Rather, knowledge is constructed by learners through an active, mental process of development; learners are the builders and creators of meaning and knowledge. Constructivism refers to “a way of knowing, that incorporates a wide range of intellectual activities, such as learning, reality-building, instructional methods, and inquiry approaches in research and evaluation” (Duffy & Cunningham, 1996)\(^\text{16}\).

Constructivism refers to, “the philosophical belief that people construct their own understanding of reality.” (Oxford, 1997)\(^\text{17}\). Constructivists believe that they ‘construct’ meaning based upon their interactions with their surroundings, rather than assimilate a body of knowledge about one’s world and environment. These interactions provide the evidences and the opportunities for experimentation with the world and thus, construct their realities.

Fosnot (1989)\(^\text{18}\) defines constructivism with reference to four principles: “learning depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than mechanically accumulating facts; meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas”. A productive, constructivist classroom, then,
consists of learner-centered, active instruction. In such a classroom, the teacher provides students with experiences that allow them to hypothesise, predict, manipulate objects, pose questions, research, investigate, imagine, and invent. The teacher’s role is to facilitate this process.

Zurita & Nussbaum (2004)\textsuperscript{19} cite the work of Rochelle and Teasley in listing the characteristics of effective constructivist working environments. These include learning being \textit{constructive, active, significant, based on consultation, reflexive and collaborative}. Thus: “\textbf{Constructive} means that the students have to modify their current knowledge schemes to integrate new information and acquire new knowledge. \textbf{Active} indicates that total student participation is expected. \textbf{Significant} refers that learning has to be with a meaning, built from the conceptual structure the student already has. \textbf{Based on consultation} points out that the child has to formulate his own questions from multiple interpretations and learning expressions. \textbf{Reflexive} shows that the student has to mirror his own experience on other students, making them experts in their own learning. Finally, \textbf{Collaborative} indicates that the child learns from others by working together on the same objective, where each group member is a potential source of information.”

\textbf{2.2.2 Constructivism –Ontology and Epistemology}

Ernst von Glasersfeld has suggested that constructivism can only be understood through considering both ontology and epistemology. Ontology, “refers to issues concerning the nature of being” (Oxford, 1997)\textsuperscript{17}. Constructivists’ notion of reality is that the true or real nature of things in the
world is knowable and independent of the knower. Glasersfeld (1995) indicates in relation to the concept of reality: “It is made up of the network of things and relationships that we rely on in our living, and on which, we believe, others rely on, too”. The knower interprets and constructs a reality based on his experiences and interactions with his environment. Rather than thinking of truth in terms of a match to reality, von Glasersfeld (1995) focuses instead on the notion of viability: “To the constructivist, concepts, models, theories, and so on are viable if they prove adequate in the contexts in which they were created”.

Epistemology pertains to the origin, foundation, limits, and validity of knowledge. “Epistemology deals with the transmission of knowledge.” (Ozmon & Craver, 1999). Epistemologically, Constructivists maintain that knowledge is constructed by the individual in an active process of interaction within particular contexts and not discovered from the world. Belanky et al. (1997) summarise the changing view of knowledge from absolute truth to contextual as “to see that all knowledge is a construction and that truth is a matter of the context in which it is embedded is to greatly expand the possibilities of how to think about anything, even those things we consider to be the most elementary and obvious. Theories become not truth but the models for approximating experience.

Constructivist epistemology assumes that learners construct their own knowledge on the basis of interaction with their environment. Four
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epistemological assumptions are at the heart of what we refer to as “constructivist learning”.

i. Knowledge is physically constructed by learners who are involved in active learning.

ii. Knowledge is symbolically constructed by learners who are making their own representations of action.

iii. Knowledge is socially constructed by learners who convey their meaning making to others.

iv. Knowledge is theoretically constructed by learners who try to explain things they don’t completely understand.

2.2.3 History of Constructivism

The concept of constructivism has roots in classical antiquity, going back to Socrates’ dialogues with his followers, in which he asked, directed questions that led his students to realize for themselves the weaknesses in their thinking. Manus (1996)\textsuperscript{23} draws a comparison between Sophists and Socratics and thereby gives a glimpse into the pre-history of constructivist versus proceduralist approaches to knowledge acquisition. Sophists believed that knowledge could be transmitted via lecture and modeling and that knowledge resided outside the person and could be acquired and used to further one’s position within the “polis”. Socratics, on the other hand believed that learning was an inner experience and that why we learned was more important than what we learned.
Giambattista Vico, in the treatise published in 1710 on the construction of knowledge commented that “one only knows something if one can explain it” (Yager, 1991). Vico’s concepts dealt mostly with the relationship between truth, knowledge and the origin of languages and the desire of the human mind to create knowledge. It is through Vico’s writings that the term ‘constructivist’ has been taken. His slogan, according to von Glasersfeld (1989), was, “The human mind can only know what the human mind has made”. Immanual Kant is another important figure often mentioned in the history of constructivist philosophy. He asserted that human beings are not passive recipients of information. Learners actively acquire knowledge, associate it with previously learned knowledge and make it theirs by constructing their own interpretation.

Though Vico is credited with coining the term ‘constructivist’, Piaget is regarded as the pioneer of the constructivist approach to cognition in this century (von Glasersfeld, 1995). His theory of knowledge, published in 1954, portrayed the child as a ‘lone scientist’ creating his own sense of the world (Oxford, 1997). Piaget felt that biological development occurs through organization and adaptation to the environment and the same occurs for cognitive development. While Piaget knew that this occurred within a social context, he maintained his focus on the individual learner.

The application of Piaget’s work to educational practice has focused on the activities of the learner. As Piaget (1973) wrote in ‘To Understand is to Invent’, “to understand is to discover, or reconstruct by
rediscovery”. Piaget advocated a system which matched the curriculum to the student’s level of development. He believed that human beings develop increasingly more complex levels of thinking in definite stages, each stage being characterized by the possession of certain schemas. Piaget believed that “teaching is the creation of environments in which students cognitive structures can emerge and change” (Joyce & Weil, 1996).27

Vico and Piaget, while not known in their times as constructivists, initiated study into the theories of knowing and creating realities. The study of their work has given rise to a number of different varieties of constructivism. The realm of constructivism can be divided and sub-divided into a number of related categories of the main principles. Radical constructivism, whole theme constructivism, social-cognitive constructivism, idea-based social constructivism - all stem from the original concepts of constructivist theories, yet, differ in the approach to defining how the knower constructs his knowledge. A primary division of the constructivist theory comes between the view of the knower as an individual - interacting within social structures, but creating his own view of reality independent of others, and the knower gaining his view of reality through a socially-mediated process. While the earliest proponents of constructivism concerned themselves with the individual, later philosophers saw knowledge construction as part of, and arising from, social interactions. Dewey and later, Vygotsky recognized that the construction of knowledge was rooted in a group context (Oxford, 1997).
**Individual versus Social Constructivism**

According to Piaget’s view of cognitive development, intelligence consists of two inter-related processes, *organization* and *adaptation*. People organize their thoughts so that they make sense, sorting out thoughts and connecting one idea to another. At the same time, people adapt their thinking to include new ideas, for new experiences provide additional information. This adaptation occurs in two ways, through *assimilation* and *accommodation*. In the former process, new information is simply added to the existing cognitive organization. In the latter, the intellectual organization has to change somewhat to adjust to the new idea.

Piaget conceived of human cognition as a network of mental structures created by an active organism constantly striving to make sense of experience. According to him, the most important source of cognition is the child himself. Piaget’s theory of cognitive development proposes that humans cannot be “given” information which they immediately understand and use. Instead, humans must “construct” their own knowledge. They build their knowledge through experience. Experiences enable them to create schemata - mental models in their heads. There are two key Piagetian principles for learning:

1) Learning is an active process.
2) Learning should be whole, authentic, and real.
Ormrod (2000)\textsuperscript{28} summarises Piaget’s basic assumptions about children’s cognitive development in the following ways:

i. Children are active and motivated learners.

ii. Children’s knowledge of the world becomes more integrated and organized over time.

iii. Children learn through the processes of assimilation and accommodation.

iv. Cognitive development depends on interaction with one’s physical and social environment.

v. The processes of equilibration help to develop increasingly complex levels of thought.

vi. Cognitive development can occur only after certain genetically controlled neurological changes occur.

vii. Cognitive development occurs in four qualitatively different stages—sensorimotor stage, pre-operational stage, concrete operational stage and formal operational stage.

Lev Vygotsky’s contribution to constructivism is next to Piaget in the development of the constructivist theory. Social constructivism acknowledges a reflexive relation between the social nature of school tasks and individual’s cognition. As Hogan (1997)\textsuperscript{29} remarks, students interpret tasks demands differently and tasks have different personal meaning for them, which in turn affect their involvement in learning, what strategies they use and how successfully they self regulate cognitive processes.
Vygotsky’s theory of cognitive development believed that everything is learned on two levels. First, through interaction with others, and then integrated into the individual’s mental structure. Therefore, social interaction plays a fundamental role in the development of cognition.

Another aspect of Vygotsky’s theory is the idea that the potential for cognitive development is limited to a “zone of proximal development (ZPD)” which is probably his best-known concept. He argues that learners can, with the help from adults or children who are more advanced, master concepts and ideas that they cannot understand on their own.

Vygotsky’s theory of learning gives more emphasis on the social context of learning. In Vygotsky’s theories, teachers and more experienced learners also have their role to play in learning, thereby interaction or collaboration can be achieved. For Vygotsky, the culture gives the child the cognitive tools needed for development. The type and quality of those tools determine to some extent, the pattern and rate of development. The kind of cultural tools include cultural history, social context, and language used by the learner.

Vygotsky’s Theory offers new visions of teaching and learning. Vygotskian classrooms promote assisted discovery and peer collaboration. Reciprocal teaching and Cooperative learning are two Vygotskian-based educational innovations which promote assisted discovery and peer collaboration. Teachers guide children’s learning with explanations,
demonstrations and verbal prompts, carefully tailoring their efforts to each child’s zone of proximal development.

John Dewey is often considered as a constructivist. His beliefs about education and ways of knowing included the premise that knowing is not done by an outside spectator but is constructed by a participant, with society providing a reference point or theory for making sense of the experience (Oxford 1997). Dewey expanded on the notion that all knowledge is constructed by the knower by including the idea that there is a relationship between the individual, the community, and the world mediated by socially constructed ideas. This brand of constructivism is sometimes also referred to as social constructivism.

In education, constructivism emerged formally as a theory of knowledge and a theory of learning during the 1980s with the works of Bruner and von Glasersfeld, which attracted the attention of educators during the early 1990s. While labelling oneself as a constructivist is now in vogue and the idea that knowledge is constructed is accepted widely, the emergence of constructivist learning theories and the constructivist pedagogies that followed created a major paradigm shift in education. Thus, greater emphasis has been placed on learners’ prior experience rather than the teacher’s and on the active construction of knowledge rather than the passive reception of information.
2.2.4 Constructivism – A Process Approach

Constructivist strategies and activities involve a process approach to learning. Applebee (1993) remarks that “rather than emphasising characteristics of the final products, process-oriented instruction focuses on the problem-solving strategies that students need to learn in order to generate those products”. And as students interact with their teacher and with each other as part of either whole class activities, small group activities, or individual activities, they practice using language in a variety of contexts developing and honing many different skills.

In process approach, Langer and Applebee (1987) remark, a context is created within which students are able to explore new ideas and experiences. Within this context, a teacher’s role in providing information decreases and is replaced by a “strengthened role in eliciting and supporting students’ own thinking” and meaning-making abilities.

In this paradigm, learning emphasizes the process and not the product. How one arrives at a particular answer, is what is important, and not the retrieval of an ‘objectively true solution’. Learning is a process of constructing meaningful representations, of making sense of one’s experiential world. In this process, students’ errors are seen in a positive light and as a means of gaining insight into how they are organizing their experiential world. The notion of doing something ‘right’, according to von Glasersfeld (1987) is to do something that fits with “an order one has established oneself”.
Constructivist activities in any subject area can range from very simple to sophisticated and complex depending on the teacher’s learning objectives. If a teacher is to devise a constructivist activity, the first thing that she has to do is establish an educational objective. The teacher would then need to think of a meaningful activity which would, at the same time, help students to reach the objective and to explore and construct knowledge based on what they are reading and what they bring to the activity.

Brooks and Brooks (1999)\(^{32}\) offer five guiding principles of constructivism that can be applied to the classroom.

- **Pose problems of emerging relevance to students:** A focus on students’ interests and using their previous knowledge as a starting point helps students engage and become motivated to learn.

- **Structure learning around primary concepts:** This refers to building lessons around main ideas or concepts, instead of exposing students to segmented and disjoint topics that may or may not relate to each other.

- **Seek and value students’ points of view:** This allows for access to students’ reasoning and thinking processes, which in turn allows teachers to further challenge students in order to make learning meaningful. For this, the teacher must be willing to listen to students, and to provide opportunities for this to occur.

- **Adapt curriculum to address students’ suppositions:** “The adaptation of curricular tasks to address student suppositions is a function of the cognitive demands implicit in specific tasks (the curriculum) and the
nature of the questions posed by the students engaged in these tasks (the suppositions).

▸ **Assess student learning in the context of teaching**: This refers to the traditional disconnect between the contexts or settings of learning versus that of assessment. Authentic assessment is best achieved through teaching; interactions between both teacher and student, and student and student; and observing students in meaningful tasks.

In the National Curricular Framework (2005) by NCERT, the constructivist approach and its implications for practice have been brought out in great detail. Some of the key principles are summarized below:

- In the constructivist perspective, learning is a process of construction of knowledge.
- Learners actively construct their own knowledge by connecting new ideas to existing ideas on the basis of materials or activities presented to them.
- The structuring and restructuring of ideas are essential features as the learners progress in learning.
- The engagement of learners, through relevant activities, can further facilitate in the construction of mental images of the relationships.
- Collaborative learning provides room for negotiation of meaning, sharing multiple views and changing the internal representative of external reality.
2.2.5 Instructional Design and Teaching

In terms of instructional design and teaching, constructivism implies instruction as a process of supporting the individual’s construction of knowledge as opposed to the conventional method of transmitting knowledge to the learner. The students negotiate within their minds, reflectively and meta-cognitively; and with others, socially, within the context of a “community of learners.” All of this is situated within the contexts of the instructional environment. Contexts from this perspective could include the people, content, materials and resources, the institution and so on.

Constructivist teaching is based on recent research about the human brain and what is known about how learning occurs. Caine and Caine (1991)\(^{34}\) suggest that brain-compatible teaching is based on 12 principles:

i. The brain is a parallel processor.

ii. Learning engages the entire physiology.

iii. The search for meaning is innate.

iv. The search for meaning occurs through ‘patterning’.

v. Emotions are critical to patterning

vi. The brain processes parts and wholes simultaneously.

vii. Learning involves both focused attention and peripheral perception.

viii. Learning always involves conscious and unconscious processes.

ix. We have at least two different types of memory: a spatial memory system and a set of systems for rote learning.
x. We understand and remember best when facts and skills are embedded in natural, spatial memory.

xi. Learning is enhanced by challenge and inhibited by threat.

xii. Each brain is unique.

According to Bentley and Watts (1994), constructivist teaching involves five steps, which are:

 ✓ Start with learners’ prior knowledge.

 ✓ Help progression through a process of ‘orientation’, ‘elicitation’, ‘restructuring’ and ‘application’.

 ✓ Design bridges to take the learner to the desired point through careful and targeted questioning.

 ✓ Different forms of active learning such as group work, cooperative learning and team projects should be used.

 ✓ Encourage students to explore ideas themselves.

2.2.5.1 Constructivist Learning Designs

The Constructive Learning Design emphasizes six important elements: Situation, Groupings, Bridge, Questions, Exhibit, and Reflections (Gagnon & Collay, 2001). A brief overview of how each of these six elements integrate and work as a whole is given below.

1. **Situation:** The situation should include what the teacher expects the students to do and how students will make their own meaning.

2. **Groupings:** There are two categories of groupings:
A. **Groupings of students** as a whole class, individuals, in collaborative thinking teams of two, three or more, and the process the teacher uses to group them. This depends upon the situation she designs and the materials available.

B. **Groupings of materials** that the students will use to explain the situation by physical modelling, graphically representing, numerically describing, or individually writing about their collective experience. The numbers of sets of materials determine the numbers of student groups formed.

3. **Bridge:** This is an initial activity intended to determine the students’ prior knowledge and to build a “bridge” between what they already know and what they might learn by explaining the situation. This might involve giving them a simple problem to solve, having a whole class discussion, playing a game, or making lists.

4. **Questions:** Questions could take place during each element of the Learning Design. The teacher needs to anticipate questions from students and frame other questions to encourage them to explain their thinking and to support them in continuing to think for themselves.

5. **Exhibit:** This involves having students make an exhibit for others of whatever findings they made to record their thinking as they were explaining the situation. This could include writing a description on cards and giving a verbal presentation, making a graph, chart, or other visual representation, acting out or role playing their impressions, constructing a physical
representation with models, making a video tape, photographs, or audio tape for display.

6. **Reflections:** These are the students’ reflections of what they thought about while explaining the situation and then saw the exhibits from others.

### 2.2.5.2 The 5 E’s of Constructivism

The Biological Science Curriculum Study (BSCS), a team whose Principal Investigator is Roger Bybee (1997) developed an instructional model for constructivism, called the “Five E’s”.

In this model, the process is explained by employing the five E’s, which are: Engage, Explore, Explain, Elaborate and Evaluate.

- **Engage** - students encounter the material, define their questions, lay the groundwork for their tasks and make connections from new to known.

- **Explore** - students directly involved with material, inquiry drives the process, teamwork is used to share and build knowledge base.

- **Explain** - learner explains the discoveries, processes and concepts that have been learned through written, verbal or creative projects. Teacher supplies resources, feedback, and vocabulary and clarifies misconceptions.

- **Elaborate** - learners expand on their knowledge, connect it to similar concepts, apply it to other situations- can lead to new inquiry.

- **Evaluate** - on-going process by both teacher and learner to check for understanding. Rubrics checklists, teacher interviews, portfolios, problem-based learning outputs and other multiple tools of assessment. Results are used to evaluate and modify further instructional needs.
2.2.5.3 The 7 Es of Constructivism

The 5 E model has turned into “the 7E Instructional Model”, suggested by Eisenkraft (2003)\textsuperscript{38}, which is about transferring knowledge laying stress on previous schemas of knowledge. This model takes shape enlarging the engage phase with “Elicit” phase and adding “Extend” phase to Elaborate and Evaluate phases. Hierarchy of the model is shown below.

- **Elicit** - In this phase the main aim is to emerge past experiences about learning and create a strong background for other phases. Beginning by only engaging the new issues with the old ones can be thought deficient in supporting the thinking abilities. For that, we should revive old information and learning experiences.

- **Engage** - First, by drawing attention to the lesson, students are engaged to think about the topic and ask their own questions. Typical activities related to this phase are asking a question, defining a problem and mind storming in adverse cases.

- **Explore** - In this phase, students have the reasoning opportunity about the key concepts required for exploring schemas and knowledge. Students should be encouraged for diverging from the main problem and reasoning for creating their own schemas.

- **Explain** - Managing scientific concepts related to the topic is important in this phase. Student should have mind structure in order to give alternative answers to the questions about the topic. And by the time they develop
new thoughts within their observations in the explore phase, new concepts can be presented.

- **Elaborate** - In elaborate phase, students think more in-depth on things they learn and apply them on different cases. They test ideas with details and explore even additive connections. Providing sympathy for lessons and diversifying student understandings are critical behaviours for a teacher in this phase.

- **Evaluate** - Learning cycle model creates specific opportunities for teachers in determining the evolution in thinking levels of the students and also evaluating their learning rates. For instance, evaluation elements like concept maps, projects and summary reports about the topics can be used along traditional assessments like quiz forms.

- **Extend** - The aim for adding a new phase to elaborate and evaluate phases is to show the teachers that applying some traditional and modern assessment ways is not the last process and underline the importance of the different applications for transferring information.

### 2.2.6 Student in a Constructivist Classroom

A constructivist classroom is a student-centered classroom. Students are encouraged to take initiative and ownership for their own learning, thereby developing their own intellectual identity. Students’ ideas are respected and independent thinking is encouraged. Students develop questions and identify issues, then gather and analyze information to create their own answers - in this way they become problem solvers.
Constructivism allows academic freedom to students, encourages cooperative learning and sharing of thinking among peers. Within the constructivist paradigm, role of the student changes from ‘knowledge acquisition’ to ‘knowledge construction’. Social constructivism not only acknowledges the uniqueness and complexity of the learner, but actually encourages, utilizes and rewards it as an integral part of the learning process (Wertsch 1997)\(^\text{39}\).

The student:

- Questions teachers’ and other students’ ideas
- Formulates and tests hypotheses
- Draws his own conclusions
- Compares his findings and results with those of others
- Demonstrates solutions and procedures
- Elaborates and interprets ideas
- Verifies and validates his own beliefs

This places the student at the central position. A constructivist student-centered approach places more focus on student’s learning than on teacher’s teaching. Students develop the habit of self-directed learning. Von Glasersfeld (1995)\(^\text{20}\) argues that: “From the constructivist perspective, learning is not a stimulus-response phenomenon. It requires self-regulation and the building of conceptual structures through reflection and abstraction”.
2.2.7 Teacher in a Constructivist Classroom

Teachers are individuals who are often drawn into teaching by a love of kids. Constructivist teachers develop skills and abilities to empower students and to make them feel competent and significant. Perhaps some of what a constructivist teacher does is intuitive. Constructivist teaching also requires intelligence, creativity, patience, responsiveness, and the ability to live with ambiguity, permitting one to spontaneously abandon a plan in order to accommodate specific individual or classroom situations. While the job of being a constructivist teacher is demanding, its value is evident in the impact on students’ learning and personal development. The most important aspect of a constructivist teacher’s job is watching, listening, and asking questions of students in order to learn about them and about how they learn so that teachers may be more helpful to students.

In von Glasersfeld’s (1995) radical constructivist conception of learning, the teachers play the role of a “midwife in the birth of understanding” as opposed to being “mechanics of knowledge transfer”. Their role is not to dispense knowledge but to provide students with opportunities and incentives to build it up. Mayer (1996) describes teachers as “guides”, and learners as “sense makers”. In Gergen’s (1995) view, teachers are coordinators, facilitators, resource advisors, tutors or coaches. Teaching from this perspective is also a learning process for the teacher. According to the constructivist theory, teachers should develop lessons that get students to collaborate and assimilate information for meaningful learning to take place.
Gurumurthy (2008)\textsuperscript{42} cites the task of a constructivist teacher in a classroom as described by Donald D. Quinn. “If a doctor, lawyer, or dentist had 40 people in his office at one time, all of whom had different needs, and some of whom didn’t want to be there and were causing trouble, and the doctor, lawyer, or dentist, without assistance, had to treat them all with professional excellence for nine months, then he might have some conception of the classroom teacher’s job.”

Wildy and Wallace (1995)\textsuperscript{43} believed that good science teachers are those who teach for deep understanding: “They use students’ ideas about science to guide lessons, providing experiences to test and challenge those ideas to help students arrive at more sophisticated understanding. The classrooms of such teachers are learner-centered places where group discussion, exploration and problem solving are common place.” A constructivist teacher is a well informed, aware and sensitive teacher who is able to engage children through well chosen tasks and questions so that they are able to realize their developmental potential.

2.2.8 Classroom Organization and Management

The organization and management of a class contribute appreciably to the creation of a classroom environment that promotes constructivist learning. A democratic classroom environment emphasizes shared responsibility and decision-making. It is generally accepted that practices which typify democratic classrooms include acknowledgement of the importance of human experience in learning, accommodation of small
groups, individuals, and occasionally, the whole class in instruction, creation of an environment that supports the active involvement of students in collaborative and empowering activities such as the exchange of ideas and opinions, and responsibility for making decisions about learning and for generating flexible rules and teacher focuses on students’ learning rather than on teacher performance (Dewey (1916)\textsuperscript{44}, Bentley & Dewey (1949)\textsuperscript{45}). Lester and Onore (1990)\textsuperscript{46} suggest that the attitudes, values, and beliefs of a teacher, specifically those related to the belief of student as constructor of knowledge, make it possible to create a democratic environment. According to the National Curricular Framework (2005)\textsuperscript{33}, “Flexible, creative classroom management is the cornerstone of any successful constructivist classroom.”

A democratic classroom is self-regulating. Rather than overtly controlling the students, a constructivist teacher structures the classroom so that students and teacher can share in the control of their environment. Students are directly involved in all matters that occur in the classroom that affect their being there, as learners and as people.

2.2.9 Evaluation in Constructivism

The Constructivist perspective allows students to give alternate solutions to a problem. Techniques which attempt to reveal the individuals construction of knowledge such as concept mapping and vee diagrams, portfolios, performance-based tests and team tests must be used in the constructivist paradigm. Evaluation of student learning, in constructivism is not judged only on the specifics of knowledge, but whether the student can
solve the problem posed with a viable solution. Formative evaluation becomes an important aspect of constructivism.

2.2.10 Advantages of Constructivism

- The learner will learn to apply their knowledge under appropriate conditions.
- Use of scaffolding, provided by teacher or group helps in individual problem solving.
- Learners will be able to develop metacognitive skills.
- Learners will get support via cognitive apprenticeship in the complex environment rather than simplifying the environment for the learner.

2.2.11 Disadvantages of Constructivism

- The learner may be hampered by contextualising learning in that, at least initially, they may not be able to form abstractions and transfer knowledge and skills in new situations.
- Learners will enjoy this new approach of discovering learning, but do not always actively construct meaning and build an appropriate knowledge structure.

2.3. CONSTRUCTIVIST-COMPUTER ASSISTED INSTRUCTION

The information age carries the potential of introducing significant changes in education, although it is unlikely that the basic functions of traditional academic institutions will be transformed. The elements of IT revolution with the power to transform education include
communication, storage and retrieval of knowledge (Castells, 2000). Students are increasingly dependent on the internet for the dissemination of their work, particularly in higher classes. IT is shaping teaching and learning and is affecting the management of academic institutions. The information and knowledge base available through the internet reflects the realities of the knowledge system world-wide. The internet simplifies the obtaining of information for the teachers as well as students. This has a democratizing effect on scientific communication and access to information.

In the 21st century, the new vision of education is to make learning accessible to all, but it is hard to reach this goal through the use of traditional methods. Besides, technology in education has the potential for improving teaching and learning. Hence, technology innovations are increasing the demand for reforms in teaching and learning approaches. That is why pedagogies of school reform are now highly influenced by and built around “constructivist” theories of learning that assume the use of technology in education (Windschitl, 2002). Therefore, educational technologies, specifically computer and the Internet technologies, have inevitably become powerful in the classroom as they change the way we teach and learn.

2.3.1 Constructivism and Computer Assisted instruction

Instruction today faces two challenges. One challenge comes from the changing perceptions of what learning is all about. The second challenge comes from the new learning opportunities that technology now affords (Salomon et al., 1991). Constructivism has presented the first challenge of
reconceptualising learning as a constructive process whereby information is turned into knowledge by means of interpretation, by actively relating it to existing bodies of knowledge, by the generative creation of representations, and by processes of purposeful elaboration (Resnick, 1989). Thus, Constructivism provides a valuable framework for using computers and other technology in productive and interesting ways.

Presenting the second challenge is the computer. Because of its versatility and accessibility, its use in education may help to shift the foci from knowledge-as-possession to knowledge-as-construction and from learning as outside-guided to learning as self-guided. It also carries with it a renewed conception of instruction that shifts attention from instruction as the imparting of knowledge to instruction as the guidance of socially-based exploration in intellectually rich settings (Salomon, 1991).

It is no coincidence that these shifts, implied by the computer, happen to be highly congruent with the constructivist principles of learning and teaching. Constructivism and computing technology, separately and often together, have remade substantially the conception of the challenges of learning, and brought about new learning possibilities for almost all teaching and learning situations, including traditional classroom teaching, distance learning and self-learning.

Constructivism provides ideas and principles about learning that have important implications for the construction of technology-supported learning environments. One of these implications is the need to embed
learning into authentic and meaningful contexts (Brown, Collins & Duguid, 1989). Here, students are required to engage actively in authentic problem-tackling or decision-making cases. There are numerous kinds of case-based learning environments. Among the better known forms are cognitive flexibility, hypertexts and anchored instruction (Jonassen, 1995). The central tenet of these forms of learning is improvement of students’ understanding and their transfer of information through exposure to the same material, at different times, in rearranged contexts for different purposes (Spiro et al., 1991).

Technology tools that aid in case-based learning include various types of simulation and strategy software or CD-ROMS, video discs, multimedia or hypermedia, and telecommunications which include e-mail and internet. These tools present benefits including the ability to obtain relevant information in the form of documents, photographs, transcripts, video and audio clips; the capability of providing virtual experiences that otherwise would not be possible; and the opportunities for students to examine a variety of viewpoints so that they can construct their own knowledge of various concepts (Rice & Wilson, 1995).

Computer-supported constructivist environments should not involve the knowledge and intelligence to guide and structure learning processes, but rather should create situations and offer tools that stimulate students to make maximum use of their own cognitive potential (Scardamalia et al., 1989).
2.3.2 Learning in Computer-supported Constructivist Environment

Computers can support the variety of ways learners construct their own understanding. Students who gather information from the Internet can be self-directed and independent. They can choose what sources to examine and what connections to pursue. Depending on the parameters set by teachers, the students may be in complete control of their topics and their explorations.

An important implication of constructivism for the construction of technology-supported learning environment is that learning is a personal, as well as a social activity. The penetration of technology into the learning process can have profound consequences for how learning takes place socially. On one hand, one can see even more individual learning in a student sitting in front of his computer. But on the other hand, the technology allows for much more diversified and socially rich learning contexts; peer tutoring via computer, computer networks, e-mail and telecommunications.

Increased recognition of the potential of computer-mediated communications, and computer-supported collaborative work has enabled building more supportive, collaborative and social learning environments called for by the constructivist perspective.

Recent growth in telecommunications has led to the use of online services, electronic networks, and the World Wide Web, readily accessible to both homes and schools. Telecommunications include e-mail and Internet access. E-mail makes online discussion groups, electronic pen
pals, student-to-student projects, class-to-class projects possible. In addition, the Internet provides many resources, including text, pictures, video, sound, and downloadable software, and is an endless source of activities and information.

Telecommunication technologies easily lend themselves to constructivist principles by providing students with opportunities to communicate with people all over the world, conduct research, discuss issues and work cooperatively. The advent of computer-mediated communication (CMC) has permitted learners, in particular, distance learners, to benefit from the shared experience of a group engaged in the same study and the opportunity to measure his ideas against those of others in the group. By way of CMC, the teaching and learning styles of both instructors and learners are transformed from information dissemination to critical inquiry and from instructor dominated to collaborative learning.

Clarifying the role of technology in learning, Duffy and Cunningham (1996)\textsuperscript{15} state that “Technology is seen as an integral part of the cognitive activity….This view of distributed cognition significantly impacts how we think of the role of technology in education and training, the focus is not on the individual in isolation and what he knows, but on the activity in the environment. It is the activity - focused and contextualized - that is central... The process of construction is directed towards creating a world that makes sense to us, that is adequate for our everyday functioning”. Thus, the task of
the learner is seen as dynamic, and the computer makes available new learning opportunities.

As Morrison, Lowther, and DeMeulle (1999)\textsuperscript{57} aptly suggest, “Technology and a constructivist approach need not be at odds with each other. If we change our view of computers from merely a means to deliver instruction to one of a tool to solve problems, then the reform movement can influence the use of technology, and technology can influence the reform of education”.

2.3.3 Role of Students

Students in computer-supported classrooms are armed with powerful tools to help them gather information, consult with colleagues, and present their findings. As their reliance on teacher becomes less, their autonomy and confidence increase. They depend more on their own initiative for knowledge creation. Computers enable students to manipulate information in a manner that accelerates both understanding and the progression of higher order thinking skills. Laney (1990)\textsuperscript{58} has reported that computers were effective in developing higher-order thinking skills, including defining problems, judging information, solving the problems, and drawing appropriate conclusions. As students gather more real world data, share their findings with learners beyond their school, and publish their findings to the world, their role broadens from investigators of other products to designers, authors and publishers of their own work.
2.3.4 Role of Teachers

Computers amplify the resources teachers can offer their students. Rather than relying on the textbook for content, computers can provide online access to content experts and up to date information from original sources. Reference materials on CD-ROMs and curriculum assistance from high quality software offer many more resource opportunities than most classrooms or school libraries could provide.

2.3.5 Advantages of Constructivist- Computer Assisted Instruction

- Students explore, experiment, construct and reflect on what they are doing, so that they learn from their experiences.
- Learners are presented with a complex and relevant problem, project, or experience that they accept as a challenge.
- Constructivism based learning environment provides them with the tools and resources that they need to understand the problem and to solve it.

2.3.6 Limitations of Constructivist- Computer Assisted Instruction

- Web sites are passive and lack interactivity, which is crucial in many learning activities such as group discussion, case study analysis, class discussion, asking questions and immediately receiving answers and instructor feedback.
- Current Internet technologies do not provide as rich a communication medium as face-to-face meetings in real classrooms provide. E.g. video
conferencing demands high bandwidth and is good only for one to one communications.

- With web based course material, the instructor is never sure whether the critical, time-sensitive material information is reviewed by all the students.

- In web-based instruction, there is no feedback loop.

### 2.4 Bloom’s Taxonomy

In an effort to explicate the specific intentions of the educational system, Benjamin S. Bloom (1956) and his colleagues published a “Taxonomy of Educational Objectives” in the cognitive domain. According to him, the taxonomy is designed to be a classification of the student behaviours which represent the intended outcomes of the educational process. His taxonomy consists of six major classes (Figure 2.11). These classes are arranged in hierarchical order from simple to complex. The most basic level, knowledge, is exemplified by the simple recall of information like specific facts, universals, methods, etc. The other levels in the taxonomy are distinguished from the first level as ‘intellectual abilities and skills’. In other words, levels 2 to 6 require ‘organized modes of operation and generalized techniques for dealing with materials and problems’.
FIGURE 2.11
Six Levels of Bloom’s Taxonomy

Knowledge is the lowest level of intellectual ability and requires only that the student knows what is being communicated. With this fundamental understanding, the student is able to translate or rearrange the information without distorting its original meaning. In order to attain the next level; the student must be able to apply the appropriate abstractions like theory, principle, idea, or method without being prompted.

Analysis implies the ability of a student to breakdown information into its constituent elements and to explicate the relationships between the various ideas expressed. In contrast to analysis, synthesis involves the process of putting together parts in order to form a whole, i.e. creating a novel pattern or structure. At this level, the student moves into the role of a ‘producer.’

The highest level within the cognitive domain, evaluation, requires that the student make both quantitative and qualitative judgments concerning the extent to which criteria are satisfied by certain materials or methods. Such evaluations are made on the basis of internal evidence such as
logical accuracy and consistency or in terms of external criteria like a comparative process.

During the 1990’s, Lorin Anderson, a former student of Bloom, working with one of Bloom's partners in the original work on cognition, David Krathwohl, updated Bloom’s taxonomy reflecting relevance to 21st century. This new taxonomy reflects a more active form of thinking and is perhaps more accurate. The new version of Bloom’s Taxonomy also called Anderson and Krathwohl’s Taxonomy is shown in Figure: 2.12.

**FIGURE 2.12**
Anderson and Krathwohl’s Taxonomy

They made some changes, with perhaps the two most prominent ones being, changing the names in the six categories from noun to verb forms, and slightly rearranging them. Evaluation moved from the top to Evaluating in the second from the top, and Synthesis moved from second on top to the top as Creating.
REFERENCES


Theoretical Overview


Theoretical Overview


