Chapter I

Introduction

The technology is entering into an era where new and challenging ideas are much needed. The creative potential of today's school going children will determine the future of humanity. Necessities of human survival provides a challenge to what man can become, at his best, and an opportunity to find new ways of helping children realize this creative potential. Though we cannot determine what man may become, but there is no proof that human evolution has reached its end.

We have to provide suitable conditions for evolution of this creative man which require some changes in education, such as change in objectives of education, in teaching strategies, in curriculum and instructional material, etc.

One of the most important changes is a revision of the objective of education. We think usually that our schools are for learning the prescribed content only. We say that we must work together and make students learn more, whereas tomorrow's schools will be designed not only for learning but also for thinking. Therefore, educational institutions are being requested to produce scholars, who can think creatively and make useful original ideas who can find more suitable solutions to impel complicated problems.

Unfortunately, we are still dealing more with learning and seldom with thinking. According to Torrance, (1967) "most of educational research is still being devoted to the investigation of the learning process or its outcomes, seldom to the thinking process".

Since the focus of this study is on impact of teaching through
computer on creative thinking, it seems better to start with defining of what we mean by “creative thinking”.

1.1 Creative thinking

A process of developing new insights, solutions and original and imaginative perspective on situations characterizes creative thinking. It has two main traits: Originality and usefulness. An idea is original when it is a new one and is useful when it can meet one of man’s needs.

John E. Arnold (1995) has defined the term creative thinking as the mental process in which past experience is combined and recombined frequently with some distortion in such a fashion that one comes up with new patterns, new configurations, new arrangements that better solve some needs of mankind. He has made a distinction between creative thinking and what he has called original thinking. According to him, original thinking produces ideas, which are new (at least to the individual concerned), even though they are not necessarily useful. An original idea that is also useful, in term of meeting one of man’s needs, is also a creative idea. Therefore, creative thinking differs from original thinking in that the idea must be useful in addition to being original.

As Reber (1985) has cited, it also differs from critical thinking that is often contrasted with creative thinking in that latter leads to new insights and solutions while the former functions to test existing ideas and solutions for flaws or errors.

There is also another distinction between craftsmanship and creativity. Because if a man is an artist does not necessarily mean that he is a creative artist. He may be just an excellent artist who follows traditional patterns and thus produces nothing original or creative.

Torrance (1962) defined creative thinking as the process of sensing gap or disturbing, missing elements; forming ideas or hypotheses
concerning them; testing these hypotheses; and communicating the results; possibly modifying and re-testing the hypotheses.

According to him, most analysts identify four steps in this process: preparation, incubation, illumination, and revision. Apparently, the process flows something like the following: First, there is the sensing of a need or deficiency, random exploration and a clarification of the problem. It follows by a period of preparation accompanied by reading, discussing, exploring and formulating many possible solutions and then critically analyzing these solutions for advantages and disadvantages. All of these steps result into a new idea. Finally, there is experimentation to evaluate this idea. Such an idea may find embodiment in every kind of human activity.

A concept, which is often mentioned in connection with creative thinking, is imagination. When we imagine something, we call its image up before our mind's eyes. Image of something that is not actually present, that is to be in the future or that existed in the distant past. We can consider imaginative thinking as characterized by responses that are low in the stimulus-response hierarchy. A response that is low in the hierarchy is less likely to occur in the presence of a stimulus, i.e. it is an uncommon response. As it was mentioned earlier, this solution should be a useful one.

When we think in different directions, sometimes searching sometimes seeking variety, it can be resulted in finding original ideas. This kind of thinking is divergent thinking, but in convergent thinking the information leads to a right answer or to a known best or usual answer. Therefore, in creative thinking, we have to think divergently as a necessity.

At this point, it can be concluded that there are some factors or conditions, which affect creative thinking positively or negatively.

Torrance (1961) says that there are some obvious blocks to the process including premature attempts to eliminate fantasy: There are
restrictions on manipulativeness and curiosity; overemphasis or misplaced emphasis on sex roles; overemphasis on prevention; fear, and timidity; misplaced emphasis on certain verbal skill; emphasis on destructive criticism; and coercive pressures from peers.

The problem, as mentioned earlier, is that our relationships with students and structure of educational institutions interfere with the process of thinking. We expect them more learning, whereas we must give them more opportunity to fill up the gap between learning and thinking.

John E. Arnold (1955) has developed a long list of factors, which he believes prevent the creative thinking. He has named them as "mental blocks". They are divided into three categories: perceptual, emotional and cultural. Here are some of blocks in each category:

A-perceptual

1- Difficulty in isolating the problem.
2- Difficulty in narrowing the problem.
3- Difficulty in observing far relationships.
4- Difficulty in not recording "trivia".
5- Failure to distinguish between cause and effect.

It seems that most of these blocks come to affect when we generalize our habits, in other word, when we want to try to apply similar methods from the past for solving a new problem.

B-Cultural blocks

1- Conformity
2- Too much faith in reason or logic.
3- Over-emphasis on competition or cooperation.
C-Emotional blocks

1- Fear of making a mistake or of making a fool of yourself.

2- Pathological desire for security.

3- Fear of supervisors and distrust of colleagues and subordinates.

As Charles S. Whiting (1961) has reported much speculation and a reasonable amount of research have been devoted to the question of what factors make an individual “creative”. No clear conclusion has been drawn about the influence that age and sex have on one's degree of creative ability. Heredity, on the other hand, does seem to have some influence on the likelihood that one will be gifted or creative.

1.1.1 Intelligence and creativity

In regard to IQ and its relationship with creative thinking, Hugh Lytton (1971) reported that above a certain ability level (say IQ 120) creative capacities no longer depend on any further addition of IQ points and divergent and convergent thinking above this line are therefore essentially independent of each other. In the absence of a certain amount of general intelligence, however, no great creative production can occur either, so that in the lower reaches of ability, the two modes of thought tend to vary in line with each other. Andrew (1930) found correlation of .15, .02 and .03 between intelligence and imagination in studies conducted on preschool children. Welch (1946) found correlation of 0.25 between originality and intelligence. Getzel and Jackson (1962) reported low correlation ranging from .132 to .378 between creativity and intelligence. The median of these correlations based on 178 studies was found to be 0.20 by Torrance (1977). But Hasan and Butcher (1966) reported correlation of 0.74 between intelligence and creativity on Scottish children.
Through reviewing of implications arising from the definitions of creative thinking, some factors seem to be characteristic of the creative person. These factors are as follows:

- Need or problem sensitivity or ability to understand that a need or problem exists.
- Idea fluency or ability to make ideas or alternatives in large quantity.
- Originality or ability to produce fresh and novel ideas or alternatives.
- Flexibility or ability to approach to a problem from different angles.
- Motivation or possessing the necessary energy to reach one forwards toward his goal.

In brief, creative people are interested in independence, unconventionality and dominance, yet are open to experience and flexibility. They also prefer complex stimulation to simpler, orderly perception and show much interests, humor and playfulness.

1.1.2 Development of creative thinking ability

As Charles S. Whiting stated (1961) that the area, which offers the greatest potential in terms of creative thinking ability, is in helping individuals to use their present level of creative ability more effectively. Few of us use even a small fraction of our present creative ability. Through proper orientation, knowledge, and use of techniques designed to overcome mental blocks and social restrictions, we can become more creative.

Torrance (1967) believed that, Children can be taught to use creative thinking abilities in acquiring even traditional school leanings, that traditional concepts of under-and over-achievement are woefully
outmoded, that learning procedures of highly creative children are quite different from those of children with high IQ but without high creative thinking ability and that many social pressures interfere with the development and expression of these abilities. The highly intelligent children, however, are described by their teacher as more desirable pupils, more intimately known, more ambitious and more hardworking or studious. In other words, the highly creative child learns as much as the highly intelligent child does without appearing to work as hard.

Although, there are many difficulties, on one hand, to strengthen major personality traits related to creative thinking, (such as independence, self-confidence, unconventionality, or risk-taking) on the other hand, schools have been dedicated to the transmission of culture and social norms, but individuals can learn to become more creative thinker and more optimistic about their creative capabilities, through practicing creative thinking exercises and activities and by internalizing attitudes related to flexible thinking.

It can be concluded that following conditions can improve creative thinking ability among students:

- Relative welfare, as Lytton (1971) has reported, family of creative children would seem to be middle-class with father having considerable autonomy in his profession.

- Stimulating problem sensitivity.

- Constructive discontent, referring to this notion that any man-made object or process may be changed for the better. The simply no believe in the impossible.

- Permissive atmosphere and appreciating creative ideas.

- Removing sanctions against questioning and exploration.
• Providing considerable autonomy to explore.
• High level of tolerance and low level of control.
• Reducing emphasis on success and giving students problems of sufficient complexity to make them think.
• Creating a climate that will permit a healthy type of individualism, of divergent thinking.
• Providing freedom of expression and effective communication.
• Giving enough opportunities to observe, to play, fantasy, and laugh.

Fraser and O'Brien (1985) have suggested that an ideal classroom learning environment facilitative of creative performance would involve high satisfaction (i.e., enjoyment of class) and cohesiveness (i.e., Friendly relationship between students) but would be devoid of high friction (i.e., aggressive behavior of students), competitiveness (i.e., importance of students achievement relative to that of their peers), and difficulty (i.e., difficulty of class work).

Arthur G. Richardson (1988) found a positive correlation between competitiveness and creativity and a negative one between cohesiveness and creativity. It may be explained in terms of how creativity is measured. The presentation of creative tasks in a class setting seemingly creates within the individual the desire not only to achieve and compete with peers but also to show a tendency to be different, i.e., to deviate from the norm.

1.1.3 Creativity: general, artistic & scientific

Any original thinking, which is systematically led to a useful new idea that can be scientifically tested and generalized, becomes a scientific creative thinking. When scientific creative thinking habituated, it becomes
scientific creativity.

Creativity, of any kind, involves an active interaction of the creative person with his environment. Whatever he creates is in response to needs, tasks, problems and challenges, which he finds himself in his environment.

Science, as Didar Singh (1981) has cited, creates a sense of a wonder and deepened man's consciousness of the world around. Art creates a sense of order, of harmony and of beauty and enriches man's emotional life. Art is man's response to nature and to the life that he has earned for himself through science. Artistic creation is based on man's emotions expressed in a beautiful and pleasant form. A scientist seeks to uncover the secrets of nature, to understand the causes of things and phenomenon so that he may learn how to control nature for the enrichment of human life. For this, science has to probe deep into nature to search for truth and this is not possible without creative imagination.

There is much difference among creative artists, writers and scientists. In science, we deal with cumulative knowledge. According to Coler (1963), science and technology are cumulative so that all prior works must be considered at least in principle. A contemporary creative writer may ignore or may not even be familiar with the previous works; a scientist cannot even complete his elementary education without utilizing the contributions of Euclid and Archimedes.

Therefore, we cannot say that products of scientist's activity are merely results of inner state of their creator. Scientist operates on some aspects of environment in such a manner as to produce a novel or appropriate product. For this, he acts as a mediator between externally defined needs and goals. He also needs to know previous knowledge and to have strong insight, which helps the matrices of thought, and create ideas in the field. Hence, insight is most important aspect of scientific
creativity.

The scientists' illumination, according to Singh, occurs only when they have spent sufficient time with the problem and have kept on worrying about it on and off during incubation period. The preparation takes a long time of getting experience, formulating hypothesis and verification. The process of scientific creativity involves systematic and logical approaches to the verification of results. The scientific creativity springs from truth and ends with truth. It is functional type of problem solving type, which necessarily involves situations and social problems with a touch of abstracts thinking ability. It helps in scientific inventions and fact-finding endeavor.

1.2 Socio-economic status

Social stratification involves the pattern of inequality, which is characteristic of all societies. All human societies from simplest and less developed to the most complex and advanced have some form of socio-economic inequality in terms of power (the degree to which individuals or groups can impose their will on others), prestige (amount of honor or esteem associated with social positions) and distribution of wealth. The economic factor is the starting point for practically all discussions of first dimension class. Prime importance is assigned to the economic base. Socio-economic status could be defined as a position on the scale that determined for its possession apart from its personal attributes or social service, a degree of respect, prestige and influence.

According to Kuppu (1962) all attempts to measure the socio-economic status are based on three assumptions as follow:

1. There is a class structure in society.
2. Status positions are determined mainly by a few commonly accepted symbolic characteristics.
3. These characteristics can be scaled and combined using statistical procedure.
Many variables have been identified in relation to social prestige. Social prestige, usually is attached to the amount of income as well as the source of income. It is also associated with type of occupation and academic qualification. Titles, type of house in which a person lives and its surrounding area, membership of some organizations, the ownership of special goods, etc. all add to the social prestige in every society. Father's occupation, parental education and family income have been broadly translated into social class-term.

The general effect of socio-economic factors is that the children of those with lower income and less education obtain less education than the children of better placed. It seems that this in turn tend to result in their aspiring for low level occupation.

It also may provide favorable or unfavorable conditions for the academic achievement and for the development of creative talent.

1.3 Attitudes and attitude change

Attitudes, according to Peter Gumpert (1997), have generally been regarded as learned predispositions that exert some consistent influence on responses toward objects, persons, or groups. Attitudes are usually seen as the products of socialization and therefore as modifiable. Because the behavior of a person toward others is often, although not always, consistent with his or her attitudes toward them, the investigation of how attitudes are formed, how they are organized in the mind, and how they are modified has been considered of great practical as well as theoretical importance.

The discovery that attitudes follow from behavior as well as vice versa emerges from the well-tested assumption that people desire to preserve logical consistency in their views of themselves and their environments. A number of theories of cognitive consistency have become important in social psychological thinking. These theories stress the idea that individuals have a personal stake in believing that their own thoughts...
and actions are in agreement with one another, and that perceiving inconsistency between one's actions and thoughts leads to attempts to reduce the inconsistency. Through research, social psychologists attempt to understand the conditions under which people notice an inconsistency and the conditions under which they will attempt to reduce it by changing significant attitudes. Studies support the consistency-theory prediction that the attitudes of a person about a group of people can often be changed by inducing the person to change his or her behavior toward the group; the attitude change represents the efforts of the person to bring his or her ideas about the group into agreement with how he has just acted toward its members.

1.4 Teaching and creativity

Effective learning takes place when pupils are actively involved in organizing and finding relationships in the information they encounter rather than being the inactive recipients of teacher delivered bodies of knowledge. This activity results in not only increased learning and retention of content but also in improved thinking skills.

In recent years, considerable emphasis has been placed on the school's role in the development of students' thinking skills. Educators are recognizing that it is no longer sufficient to simply teach students what they should know, but in addition, they must be taught how to know.

The idea of creativity as a form of learning is not yet common. It can be defined as creative self-direction, which means a level of learning that extends cognitive and affective conceptualizations to generate self-determined experiences that are creative for the individual. Teachers can arrange their lessons so that divergent thinking and learning are likely to occur.

Tumin (1954) published a theoretical article in which he proposed a list of obstacles to creativity including: (1) an exclusive quest for certainty, (2) an exclusive quest for power, (3) an exclusive quest for meanings, (4) an exclusive quest for social relations, and (5) a pathological or exclusive
rejection of social relations. This constructive or deconstructive interaction between the social environment and an individual’s creative production may be established within the time-space limitation of the school. Tumin’s rationale suggests that the individual needs to find a balance in his social interactions between over-responsiveness to the wishes of others, over-conformity in an effort to gain the approval of others, and a pathological withdrawal from social relationships and communications. Stated positively, the personal-social need of the creative individual seems to involve freedom to seek and interact with other people, accompanied by freedom to assert one’s own identity.

According to Tumin, teachers and counselors can help creative potential to flourish by reinforcing, as frequently as possible, each pupil’s efforts to find the freedom to choose or to reject social pressure. This teaching of social interaction is much more critical, complicated, and more vital than teaching students to get along well with others. The sequence of conceptualizations that are basic to teaching (and learning) creative self-direction maybe summarized as follow: (1) creative children may be identified in school groups by productions that demonstrates fluency, flexibility, and originality, (2) their responses are so far removed from the model patterns that they, personally, may be misinterpreted and rejected by others, (3) creative motivation may be related to the kind of reinforcement they get from a personal-social balance between excessive dependence on, or pathological withdrawal from social relations, and (4) teaching constructive social interaction may help to give each student the freedom he requires to become self-directing and productive.

One of initial attempts to stimulate the production of creative ideas actually was made in American industrial firms by introducing the brainstorming approach. The main object of this approach is to facilitate the expression of the preconscious imagination in a group, by deferring conscious critical evaluation.
According to Eggen, et al. (1988) optimal development of students’ intellectual abilities occurs in the classroom when learners are provided ongoing opportunities to practice these skills across diverse areas of curriculum. They believe that no single approach to teaching is appropriate in all situations, and consequently, effective teaching requires alternative strategies to accomplish different goals. The best technique is the one, which is most effective for reaching a particular goal in a given situation only when teachers are aware of different types of content can they think in terms of a “Best” technique. They stated that the most efficient way to provide the needed experience is by integrating the skills into the regular curriculum. This is important for several reasons. First, this approach allows teachers to help students develop their thinking skills without sacrificing content. This not only allows teachers to develop both important goals but also insures many opportunities for ongoing practice. An alternative approach is to deal with thinking as a separate part of the curriculum, such as a course in “thinking”. This approach has several drawbacks. First, thinking and content are literally inseparable. When students practice the skill, they must practice them on some form of knowledge. As they stated, thinking is not done in a vacuum. A separate approach to thinking skills also is less likely to succeed, because thinking skills complete with other areas for time, a win-lose relationship develops. As more time is devoted to one area, less time is devoted to the other.

1.4.1 Science and Physics teaching and creativity

Science seeks knowledge and understanding of the world and of life itself by a method, which consist essentially of careful observation and classification of phenomena, of experiment, and of the formulation of so-called laws, which summarize our knowledge of groups of observed facts.

The teaching of any subject at school is usually justified or defended for cultural, disciplinary, and utilitarian reasons. Science can justify its inclusion in the curriculum on each of these grounds. Science teaching in a
school has a twofold function to perform. It must give the student a systematic training in careful observation, in experiment, and in the estimation of the relative value of results. It must provide a knowledge of the material world and of the forces of nature for all. At the same time, for the small proportion of pupils who will later become scientists, it must lay a sound foundation for more advanced work.

Considered as a mental discipline, science requires exact and accurate observation, care and thoroughness of technique, the logical interpretation of data and the intelligent estimation of the reliability of results. The contribution to development of such desirable qualities in students should be a conscious aim of the teacher.

There are many studies dealing with the relationship between creativity and other psychological constructs, but there is hardly any study giving relationship of Physics teaching and general or scientific creativity except one or two slightly related studies giving the relationship between learning tasks, like problem solving, on the one level and creativity on the other. Problem solving is an inferred change in human capability that results in acquisition of a generalizeable rule, which is novel to the individual which cannot have been established by direct recall and which can manifest itself in applicability to the solution of a class of problems. Problem solving is not simply a matter of application of previously learned rules. It is also a process that yields new learning.

Some studies as cited below indicate the research trends regarding learning task in relation to creativity.

Maier and Janzen (1970) concluded that superior problem solvers also generate solutions that are rated as creative when several solutions to a given problem are possible.

Treffinger and others (1974) studied the effectiveness of self-instructional material with or without the discussion by teachers and concluded: (1) both the PTCP (Purdue creativity training project) and PTP (productive thinking program) have shown significant enhancement of fifth
grade children's divergent thinking abilities (particularly verbal abilities) and creative problem solving, (2) the PTP, originally designed as a self-instructional program, appeared to be less influenced by variations in rate of presentation, teacher participation, and teacher's level of divergent thinking.

However, the results of Anthony and Hudgins (1978) research indicated that the group of trained poor problem solvers remained similar to the untrained poor solvers in performance.

1.5 Computer and education

Human communication has passed through four distinct revolution i.e. specific skills of complex speech, the art of writing, printing press and electronic which gets complicated through computer.

Computers, according to Biswas (1994), are electronic mechanism designed to process information at speed almost equal to that of light. A computer embodies five essential ingredients such as input, central processing unit containing arithmetic/logic circuits, memory or storage, control, and output. The basic means of communication are alphabetic symbols, which are combined to form words. These words are then combined in a syntactical way to form sentences, which comprise complex thoughts. There are three categories of computer: mainframes, mini computers and microcomputers. The basic distinction among these categories refers to the amount of "memory" each has or the amount of information that can be stored. The microcomputer has emerged as the most practical type of computer for classroom instruction.

Teachers can do two things with a computer:

- Teaching their concerned subject by using computers
- Teaching about the computer.

The first one, however, depends upon the available software, which
is the computer program that tells the computer what to do. Teaching with the help of computer is called computer-assisted instruction (CAI).

Although computers can do a number of things for the learner, but their interactive aspect is very important. Learner and computer can engage in the learning process. Pupil has the opportunity to grow without a great deal of teacher stimulation.

There are, however, many different modes of interaction between learner and computer. Some of them are as follows:

1-drill  2-practice  3-problem review  4-diagnosis and prescription  5-tutorial  6-fact finding  7-gaming  8-simulation  9-computation  10-logical problem solving  11-exploration.

1.5.1 Computer as an educational medium

As it was mentioned earlier, teachers can use computer as an educational medium. An educational medium, according to the John Self (1983) is a device through which (absent or present) teachers are said to communicate with pupil, like watching a televised lecture by an Open University student. An educational media has some characteristics and functions as follows:

A-Characteristics;

1-It is a device (a piece of hard ware) through which some educational materials presented in some way.

2-It provides indirect or mediated experience rather than direct experience.

3-It not only represents itself but also refers to something else-so, for example, a computer studied solely as a computer would not be regarded as an educational medium.
B-Functions:

1- Engage the student's motivation.
2- Recall earlier learning.
3- Provide new learning stimuli.
4- Activate the student's response.
5- Give speedy feedback.
6- Encourage appropriate practice.
7- Sequence learning.
8- Provide a resource.

Computers as media have also some more capabilities, which might be useful in education. They are fast; i.e. they can do numerical calculation and information searching much faster than human can. They can generate audio and visual effects. They are relatively cheap, small and reliable (in comparison to that of 20 years ago). They are interactive and can react sensibly. They can process symbols through programs and finally their programs are modifiable.

According to G. Salomon (1989) computer must be seen as part of the wider category of instructional technologies. Each technology whether books, television, pocket calculator, or microscopes, has some unique attributes which, given appropriate modes of usage, might "make a difference" in learning. However, the unique attributes of technologies ought to be integrated into some more general, multidimensional map, so that each technology and each technological use in instruction could be placed vis-à-vis other technologies. He says such a map would entail at least four dimensions along which one could align various technologies and point out their unique attributes. These dimensions are: Information or the particular content that a technology can present; Symbolic modality or
symbol system of information presentation, like word, picture, number, space, tone, and so on; Activities a technology requires or affords: Viewing, reading, measuring, testing hypotheses, reconstructing and the like; Relations that become possible between the student user and the technology.

As Salomon (1989) has stated all other instructional technologies are restricted to particular kinds of symbol systems and hence to a limited range of contents. Computers on the other hand are not limited to either one. They are tools that allow a large variety of contents and symbolic modes. They also can represent same information in different modes. Even more importantly they differ from other technologies in the variety and kinds of activities that they afford ranging from responses to questions as in drill and practice programs, to autonomous hypothesis testing in simulations; from discovery like activities via game playing to rigorous, logical planning as in programming; and from writing and revising to categorizing and calculating. Finally, computers allow the development of partner like interactive and individualized relation with the user, which no other technology can.

1.5.2 Computer assisted instruction (CAI)

It will be useful, to offer some definitions of CAI and other kinds of learning activities involving computers. As Kulik; Kulik and Bangert-Drowns (1985) stated “the terminology in the area is open to dispute”. This is putting it mildly. Those trying to obtain precise sense of a set of terms used by educators and researchers – (computer-assisted instruction, computer-base instruction, computer-based education, computer managed instruction, computer-enriched instruction)– can easily become confused. The following definitions are a synthesis of those offered by Bangert-Drowns, et al. (1985), Batey (1987), Grimes (1977), and represent
commonly accepted (though certainly not the only) definitions of these terms:

- Computer-based education (CBE) and computer-based instruction (CBI) are the broadest terms and can refer to virtually any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications. These terms may refer either to stand-alone computer learning activities or to computer activities which reinforce material introduced and taught by teachers.

- Computer-assisted instruction (CAI) is a narrower term and most often refers to drill-and-practice, tutorial, or simulation activities offered either by themselves or as supplements to traditional, teacher directed instruction.

- Computer-managed instruction (CMI) can refer either to the use of computers by school staff to organize student data and make instructional decisions or to activities in which the computer evaluates students' test performance, guides them to appropriate instructional resources, and keeps records of their progress.

- Computer-enriched instruction (CEI) is defined as learning activities in which computers (1) generate data at the students' request to illustrate relationships in models of social or physical reality, (2) execute programs developed by the students, or (3) provide general enrichment in relatively unstructured exercises designed to stimulate and motivate students.
As Douglas N. Arnold (1997) has reported, the diverse and rapidly expanding spectrum of computer technologies that assist the teaching and learning process. CAI is also known as computer-aided instruction. Examples of CAI applications include guided drill and practice exercises, computer visualization of complex objects, and computer-facilitated communication between students and teachers. The number of computers in American schools has risen from one for every 125 students in 1981 to one for every nine students in 1996. While the United States leads the world in the number of computers per school student, Western European and Japanese schools are also highly computerized.

Information that helps teach or encourages interaction can be presented on computers in the form of text or in multimedia formats, which include photographs, videos, animation, speech, and music. The guided drill is a computer program that poses questions to students, returns feedback, and selects additional questions based on the students' responses. Recent guided drill systems incorporate the principles of education in addition to subject matter knowledge into the computer program.

Computers also can help students visualize objects that are difficult or impossible to view. For example, computers can be used to display human anatomy, molecular structures, or complex geometrical objects. Exploration and manipulation of simulated environments can be accomplished with CAI - ranging from virtual laboratory experiments that may be too difficult, expensive, or dangerous to perform in a school environment to complex virtual worlds like those used in airplane flight simulators.

CAI tools, such as word processors, spreadsheets, and databases collect, organize, analyze, and transmit information. They also facilitate communication among students, between students and instructors, and beyond the classroom to distant students, instructors, and experts.
CAI systems can be categorized based on who controls the progression of the lesson. Early systems were linear presentations of information and guided drill, and control was directed by the author of the software. In modern systems, and especially with visualization systems and simulated environments, control often rests with the student or with the instructor. This permits information to be reviewed or examined out of sequence. Related material also may be explored. In some group instructional activities, the lesson can progress according the dynamics of the group.

1.5.3 CAI effectiveness

CAI can dramatically increase a student's access to information. The program can adapt to the abilities and preferences of the individual student and increase the amount of personalized instruction a student receives. Many students benefit from the immediate responsiveness of computer interactions and appreciate the self-paced and private learning environment. Moreover, computer-learning experiences often engage the interest of students, motivating them to learn and increasing independence and personal responsibility for education.

Although it is difficult to assess the effectiveness of any educational system, numerous studies have reported that CAI is successful in raising examination scores, improving students' achievement and attitudes, and lowering the amount of time required to master certain material. While study results vary greatly, there is substantial evidence that CAI can enhance learning at all educational levels.

In some applications, according to Douglas N. Arnold. (1997) especially those involving abstract reasoning and problem-solving processes, CAI has not been very effective. Critics claim that poorly designed CAI systems can dehumanize or regiment the educational experience and thereby diminish student interest and motivation. Other
disadvantages of CAI stem from the difficulty and expense of implementing and maintaining the necessary computer systems. Some student failures can be traced to inadequate teacher training in CAI systems. Student training in the computer technology may be required as well, and this process can distract from the core educational process. Although much effort has been directed at developing CAI systems that are easy to use and incorporate expert knowledge of teaching and learning, such systems are still far from achieving their full potential.

As American Federation of Information Processing societies (AFIPS) (1986- P171-2) have reported, computer, recently have begun to extend the mental capabilities of human. Computers have been programmed to do tasks that are more complex. This expanding relationship between man and computer is called human computer interaction.

CAI has a capacity to initiate flexible interactions with the student, which is not found in the other teaching machine. According to Biswas (1994), learner and computer can be engaged in the learning process. The learner becomes intellectually involved and has the opportunity to grow without a great deal of teacher stimulation. In a definite sense, this interaction becomes a personal experience. The computer is versatile in regard to videotape players, electronic musical equipment, physical education monitoring equipment and so on. It becomes an invaluable teaching tool on both a personal and collective scale.

A typical CAI installation consists of individual learning booths each with a console. The student is seated. There is a monitor screen before him for displaying information. Before he starts a program, the student checks in, with the computer by showing his ID number. This connects him with his part of the learning program. A complete package of information stored in a system is presented sequentially. This information could take the form of video tape recording, slides, motion pictures, film
film strips' etc. Pupil puts questions, computer responds by printing out comments, answers and questions. Sometimes the student may write directly on the cathode ray tube, display screen with a "light pen". His answer will be picked up by the computer and evaluated when he has finished. The computer assigns him the next program records his progress and prints out a report for his teachers. The CAI starts by identifying the way a student seems to learn best. It reviews his past history of learning and presents a program accordingly. This can be done with all students who have taken the computer course previously. This information may be re analyzed, much of teaching strategies, which were not effective, may be rejected, and strategies, which have succeeded, may be continued (Deepa Sikand, 1995). CAI therefore can be regarded as "the use of a computer to improve the student's interaction with his subject matter, materials, and teachers".

1.5.4 CAI and creative thinking

Some researchers have claimed that computers as instructional technologies can extend in some ways our mental capacities. According to Salomon (1989), they are not only interactive instructional devices but also useful tools that extend in many important ways our mental capacities. As such, they amplify learners' capacities, allowing them to carry out tasks like hypothesis generation and testing, using expert logic that no other device or method affords. Furthermore, they serve as possible models for certain kind of thinking that learners could use to discover powerful ideas with, as well as emulate, internalize, and use as newly acquired mental tools.

Constructivists say that thinking is based on perception of physical and social experiences, which can only be comprehended by the mind. The mind, in effect, filters input from the world to make interpretations, which then form a knowledge base that is personal and individualistic. Papert (1980) developed a computer language "Logo" which is a primary example
of an application of constructivism based on "microworlds". A micro world is a small but complete subset of reality in which one can go to learn about a specific domain through personal discovery and exploration. According to Papert, it should meet four criteria: usefulness, generality, simplicity and being syntonic (moving from the known to the unknown.) He believed that computers, with suitable software, could promote syntonic learning by providing children with extended opportunities to explore aspects of the world previously unavailable to them. He also believed that computer can allow us to shift the boundary separating concrete and formal. Knowledge that was accessible only through formal processes can now be approached concretely.

Knight and Knight (1995) asserted that computers have a valuable role in teaching children to think. As they reported, there is currently much research (e.g. Turkle, 1984; Lawler, du Bonlay, Hughes and McLeod, 1986) to support the notion that children need to be encouraged to think critically about information, solve problems and reflect. As children solve problems, they make decision and evaluate their effectiveness individually and with others. Problem solving situation can promote initiative, cooperation, independence and curiosity, as when using some software program which encourage young children to develop their own strategies in solving picture, word and sentence problems. Challenging tasks and a responsive environment enhances children's sense of competence.

Computers, according to Biswas (1994), have excellent potential for abstract thinking because the learners can compare relationships in reference to computer games as well as the concepts involving such academic area as Biology, Economics and Physics. By creating models utilizing logic, the learner puts to use thoughts, which might have remained inert if they were only read but not applied.

Nastasi and Clements (1992) examined group differences in social cognitive behaviors exhibited by students in computer based writing
environments and the role of these behaviors in accounting for post-treatment differences in higher-order thinking. Students in computer based writing exhibited more work-related and off-task behavior, information seeking from partner, and cognitively based resolution of cognitive conflicts and support was provided for the mediational role of information seeking social negotiation of social conflict and cognitively based resolution of cognitive conflict.

Mevarech and Kramarski (1992) investigated the effects of different cooperative Logo environments on creativity and interpersonal relationships among students. They found that students in Logo environments scored higher on several aspects of creativity: Figurative originality, Verbal Flexibility, and verbal originality than did students in the control group.

Geban and his colleagues (1992) investigated the effects of the computer-simulated experiment (CSE) and the problem solving approach on students' chemistry achievement, science process skill, and attitudes toward chemistry at the high school level. Two experimental groups using the CSE and problem solving approaches were compared with a control group using the conventional approach. The CSE approach and the problem solving approach produced significantly greater achievement in chemistry and science process skill. The CSE approach produced significantly more positive attitudes towards chemistry than the other two methods, with the conventional approach being the least effective.

Scott (1991) through his research concluded that faculty and staff members use their personal computers in liberating and creative ways and that they essentially use computers for intrinsically motivating reasons.

Grubb (1977) has claimed that historically, programmed instruction or computer assisted instruction (CAI) author/experimenter, through the program, wanted to maintain strict control over the learner and the learning
environment. The computer has long been viewed as the idea-controlling device with its stored programs' timing devices and large memory. If this would be true, it can turn to a negative factor for promoting creative thinking.

Nielsen (1986) described a process of pupils working with computer. His description demonstrates that the pupils have great difficulties in working with computer and learning programming. However, according to him, much research leaves the general impression that students do not encounter many problems when working with computers. Programming challenges higher mental function, and ensures a cognitive development, which has general value: a procedural thinking, which may be transferred to other areas in the child's life. The implication is that the learning process is of "osmotic" character, "like learning French by living in France, without being taught."

With the work process described as point of beginning, a cognitive model was presented which was founded in human interaction. The model operates with three fundamental ways of cognition: the sensori-motro, the emotive and symbolic—the latter seen here as languages. Based on this model, the theoretical frame of cognition worked within much research was being questioned.

Nielsen (1986) argued that working with computers, learning programming demands much teaching, hence human interaction, not the computer, is the basis for cognitive development and education, and this is not a challenge, which the computer can meet alone.

These arguments raise the more general question of whether computers could serve not only as superb instructional devices but also as unique cultivators of mental skills and strategies. According to Salomon, (1989) scholars have often suggested that such activities as programming could potentially in students, develop procedural logic; planning ability,
clarification of thinking and self-regulation. Unfortunately, most research to date, according to him, has not succeeded in providing persuasive evidence that such effects are forthcoming.

1.6 Literature review

1.6.1 Teaching method and creativity

Alan Joseph McCormack (1969) investigated the effects of a modified elementary science education methods course on creative thinking, self-evaluation and achievement. Subjects were 30 experimental and 39 control undergraduate elementary science education methods course students. Controls were given usual laboratory sessions and written assignments. Experimental laboratory activities included brainstorming, inquiry training, problem analysis and creative thinking exercises. Analysis of covariance of pre- and posttest Torrance Tests of Creative Thinking (TTCT) scores indicated experimental group showed superior gains in fluency, flexibility and originality. Analysis of covariance of modified Science Education Achievement Test (SEAT) scores indicated no group achievement differences. Pearson-product-moment correlation was significantly negative for TTCT and SEAT posttest scores. The t-tests of researcher constructed Self-Evaluation Inventory and Course Evaluation Instrument scores showed no differences in achievement self ratings of cognitive objectives; significantly higher experimental self ratings of affective objectives; and lecture-discussion sessions rated significantly higher by experimental group. Investigator concluded that creativity could be improved without subject matter achievement loss.

1.6.2 Computer assisted instruction and creativity

Joan K. Gallini (1983) reported that computer-assisted instruction (CAI) contributes to a creative environment for students with varying
abilities by encouraging student self-selection, exploration of new ideas and divergent thinking skills, and interaction between tutor and learner.

Mevarech and Kramarski (1992) investigated the effects of different cooperative Logo environments on creativity and interpersonal relationships among students. They found that students in Logo environments scored higher on several aspects of creativity: Figurative originality, Verbal Flexibility, and verbal originality than did students in the control group.

Gary Shank and others (1994) discussed importance of concept of adductive reasoning for instructional designers in education; and described the development of a computer program called the Adductive Reasoning Tool (ART) that helps students learn and understand adductive logic.

It is evident that there are many studies dealing with the effects of CAI on some variables such as; learning rate, retention, academic achievement, attitude (see a summary of these studies under the title "CAI related research works on other variables"), but there is hardly any study giving effect of CAI on general or scientific creativity except one or two.

1.6.3 Intelligence and creativity

Guilford (1950) predicts the relationship between creativity and intelligence to be low which has been investigated through various correlational studies.

Guilford et al. (1951-1952), Wilson et al. (1954), and Cropley (1966) demonstrated the existence of distinct factors of creativity and intelligence through factor analytic studies.

Neer and Stein (1955) conducted a study to find the relationship between intelligence and creativity among 64 scientists engaged in
industrial research. Highly intelligent scientists were found superior in scientific creativity.

Wall (1960) postulated that creativity is likely to result from a well-stored mind and that relatively high intelligence is necessary for this as well as fineness of perception.

Getzels and Jackson (1962) reported positive but low correlations (.132 to .378) between measures of creativity on the one hand and intelligence on the other, which leads to infer that while creativity is slightly related to intelligence, it really constitutes a separate cognitive factor which owes little to conventional intelligence.

Findings of Ripple and May (1962) and Yamamoto (1965) did not confirm to the view that creativity is an entity independent of other facets of human intellect.

Torrance (1963) in his partial replication of Getzels and Jackson’s study did not come across significant differences in the achievement of high creative and high intelligent groups in six out of eight such replications. Lait’s findings (1964) also supported the Getzels and Jackson’s results.

Studies of Sultan (1962), Yamamoto (1964) and Anderson (1965), Kogan (1971), Dacey and Madaus (1971), favored evidence of creativity as a separate dimension of intellectual functioning.

Burt (1962 & 1964) pointed out that there is no agreement among theorists as to whether there is a separate intellectual capacity appropriately labeled as “creativity” or “divergent thinking”. He attributed it mainly to the operation of general ability rather than some separate and distinct intellectual skills.
Ketcham and Kheiralla (1962) found fifty-four out of sixty four correlations between the scores on intelligence test (Stanford Binent) and a battery of creativity test.

In addition, Taylor (1964) in his research on creativity found that lower the intelligence level of student, the little the performance on scientific creativity test.

Schamdel et al. (1965) in one study compared performance of 31 gifted seventh graders on test of measuring various selection aspects of creativity with those of all the children in 7th grade (n=403). Gifted group with high I.Q. was found significantly superior on the measures of originality, sensitivity to the problems and conceptual foresight.

Hasan and Butcher (1966) reported a correlation 0.74 between the two constructs for Scottish children. Ginsberg and Whittmore (1968) obtained a correlation of 0.60 for an Australian sample and concluded that tests of creativity and intelligence measure somewhat different albeit overlapping abilities and warned that the case for creative thinking should not be overstated.

Kurtzman (1967) compared three groups of adolescents with different levels of creativity in science. The results indicate that more creative science students tend to be more intelligent and vice versa.

However, Madaus (1967a & 1967b), Dacey et al. (1969), and Dacey and Madaus (1971) attributed the phenomenon of high correlation to the interactional effect between the method factor related to both the measures rather than to a higher correlation between the two.

Barron (1969) observed that a specific minimum IQ is probably necessary intrinsically creative activities in order to engage in the activity at all, but beyond that minimum which often is surprisingly low, creativity has little correlation with scores on an IQ test.
Cave (1970) investigated the creativity-intelligence relationship and identified factors representing creativity, verbal relations and non-verbal reasoning. Although a distinct creativity factor was found, the intercorrelations among the promax factors were quite substantial. Cave reported correlations of .61 and .66 between creativity and verbal relations, and creativity and non-verbal reasoning factors respectively. These results suggest that creativity as operationally defined by Cave may be somewhere between the proposition that creativity is independent of intelligence and that creativity is essentially part of abstract intelligence.

Rossman and Hasn(1972) observed that creativity can probably be regarded as independent of intelligence in case of engineering students.

Mc Alpine (1972) undertook a major piece of research on the fluency and flexibility of thinking of secondary school students with high ability in science in New Zealand, U.S.A and U.K. Variables included fluency, flexibility, intelligence and other personality factors. Positive correlation was found between intelligence and flexibility in this study.

Kazelskis et al. (1972) findings conformed to the proposition that creativity and intelligence are two distinctly identifiable dimensions. Foster (1971) reached at a conclusion that tests of creativity measure different attributes from those measured in conventional tests of intelligence and that the two sets of measures have some variance in common which may be attributed to general mental ability. His findings conform to the view that creativity is highly complex involving constituent subfactors, which reveal themselves as specific content factors.

Krajkovich (1978) also found significant relationship between scientific problem solving ability and intelligence.

Starr and Nicholl (1978) administered a test of creativity, intelligence, and attitude towards science to a group of 110 students. Intelligence was related to scientific creativity and scientific attitude.
James A. Wakefield and Nancy A. Goad Jr. (1981) reported that creative persons are characterized by introversion, neuroticism, psychoticism, and moderate to high intelligence.

In a study by Houtz and Denmark (1983) a Classroom Activities Questionnaire (CAQ), the Torrance test of creative thinking verbal form and several verbal maze problem-solving tasks were administered to 207 students in grade 4-6 from 14 sub-urban middle classrooms. Problem solving ability was related only to intelligence and ideational fluency related significantly to student’s perception of emphasis on higher level thinking skills in the classroom and positive classroom climate.

Jhaj (1983) studied the general intelligence and achievement in relation to scientific creativity. He compared the cognitive and non-cognitive factors of 140 scientifically creative and 140 non-creative high school students. Students were administered a test of general mental ability and measures of scientific creativity. Achievement scores were obtained by taking the average of annual and semiannual examination marks. Results of a Varimax factor rotation analysis indicated significant differences between the creative and non-creative group on the various cognitive and non-cognitive factors investigated.

Sansanwal and Gurpal (1983) compared 30 scientific ninth grader students of higher and lower intelligence by administering tests of intelligence and creativity. ANOVA of their study also showed no significant differences in mean fluency, flexibility, originality or total creativity on the variable of intelligence.

According to Greenbowe (1984) in solving Scientific and Mathematical problems, the content of knowledge and level of intellectual development, contribute highly significantly.

Kreshner and Ledger (1985) in their study of the effect of intelligence on students’ creativity found that it had an effect on different
dimensions of students’ creativity. They further suggested that performance on each of the creativity subtests might be strongly influenced by different psychological, intellectual and social factors.

Raina (1986) found that all the three components of scientific creativity viz originality, fluency and flexibility are positively related to intelligence.

Bindu (1993) observed that significant differences on the criterion variables of scientific creativity were found out due to variable of intelligence in case of urban sample high and low intelligence groups differed significantly as mean scores between these two groups were found to be significant. In case of rural sample, also significant mean differences were found in scientific creativity between high and low intelligence groups. Like urban sample, in case of rural sample also, high intelligent group scored higher mean value as compared to that of low intelligent group on scientific creativity test.

Karen D. Fuchs-Beauchamp (1993) studied 496 children seeking admission to a special program for gifted preschoolers, found that creativity (as measured by the Thinking Creatively in Action and Movement Scale) was significantly related to intelligence (as measured by standard IQ tests) when IQs were less than 120 but was not related at higher IQ levels.

Different studies conducted in the field of intelligence in relation to scientific creativity are limited and inconclusive. There is, therefore, a need to explore this field of research further.

1.6.4 Attitudes

As it was cited previously, attitudes have been regarded as learned predispositions that exert some consistent influence on responses toward objects, persons, or groups. Attitudes are usually seen as the products of
socialization and therefore as modifiable. Because the behavior of a person
toward others is often, although not always, consistent with his or her
attitudes towards them, the investigation of how attitudes are formed, how
they are organized in the mind, and how they are modified has been
considered of great practical as well as theoretical importance.

Since there are many studies dealing with the attitude as a dependent
variable which is affected by some other variables, but there is hardly any
study giving relationship of attitude as an independent variable with
general and scientific creativity except one or two slightly related studies
giving the relationship between attitude on the one level and creativity on
the other.

A. Grewal (1980) reported that the generalized attitude towards
science is moderately correlated with scientific creativity. The correlation
between scientific creativity and attitudes towards science was 0.33. She
suggested that since there is positive relationship between the variables of
scientific creativity and attitudes towards science, it would be desirable if
the science teachers encourage open-ended questions in science subjects, to
generate new and divergent ideas. Teachers may also help to develop
positive attitude towards science by holding free discussions on positive
gains made by the humanity from the study of science because this will
ultimately enhance their creative performance in science.

1.6.5 Socio-economic background and creativity

It seems reasonable to assume that the socio-economic background
may provide favorable or unfavorable conditions for the development of
creative talent.

Knapp, Goodrich (1952), Kleusmeier, and Wiersma (1964) reported
that children in a large city did as well as their small town counterparts on
convergent thinking, but less well on divergent thinking. According to
them, the finding is intriguingly reminiscent of the old claim that most scientists came from rural areas.

Thistlethwaite (1958a & 1958b) indicated that clearly differentiated patterns of students’ cultures and faculty cultures were associated with productivity (in terms of doctorate) in the arts, humanities, and social sciences.

Marksberry (1963) observed that rural situation provides a face-to-face contact with nature, which is a constant stimulus to some kind of originality and inventiveness. However, contrary to this, rural environment also presents a monotony of activities and occupations as well as dearth of new information and knowledge. The resultant effect of challenging and realistic environment on the one hand, and monotony, dearth of information and opportunity on the other hand, has yet to be explored in specific and experimental situations.

The environmental set up of urban people comprises altogether different elements. Marksbery (1963) quoted Dewey according to whom large-scale machine production and urbanization of population tend to produce homogeneous mental diet and restrict mental independence. Urbanization amounts to automation, which according to Fromm (1941) is a risk for democracy, because it makes individuals incapable of thinking and making free choices.

To test hypotheses related to the creative thinking of children from different socio-economic backgrounds, Anita O. Solomon (1967) administered tests of creativity and of intelligence to 722 first, third, and fifth grade children from different socio-economic backgrounds. Boys and girls in each grade were tested for verbal intelligence (as measured by the Peabody picture vocabulary test), and creativity (as measured by the Torrance tests of creative thinking, figural form A and verbal form B). The Torrance test scores had greatest relationship to the combined independent
variables (sex, intelligence, and socio-economic background) at the earliest years of school. These relationships decreased as the age and the grade level of children increased. While significant relationships were found between socio-economic status and creativity when other variables were held constant, these relationships did not follow a consistent pattern. The incidence of these significant relationships tended to decrease with increasing age and grade level. These findings indicated that the Torrance test materials were relatively neutral toward different socio-economic classes. Scores were completely uncorrelated with intelligence tests, confirming the importance of emphasizing creativity as a separate dimension of thinking.

Tyler (1969) suggested that the following probable factors may be worthwhile for explaining differential levels of creativity among rural and urban population: (a) selective migration, (b) contents of tests in favor of a particular environment-rural or urban, and (c) educational facilities or handicaps. The natural surroundings and cultural environments may have a bearing on the development of creativity and could thus explain differential distribution of creative talent.

Regarding the interrelationship between social class and creativity, though both Nuss (1972), (as quoted in Foster 1971) and Rivelen (1969) (as quoted in Foster 1971) found that highly creative pupils come from higher social class group than low creatives, yet both Foster (1971) and Torrance (1977) reported no relationship between the two. Torrance (1977) observed that a number of additional studies have reported essentially the same verdict of no racial or socio-economic bias.

Researchers note that CAI confers greater benefits on economically disadvantaged students than those from backgrounds that are more privileged. Lower SES students, too, benefit greatly from opportunities to interact privately with CAI drill-and-practice and tutorial programs.
Mark A. Runco (1993) cites reasons to be optimistic and to be concerned about the creative potential of at-risk and disadvantaged students. Reasons for optimism include the wide distribution of creative potential, the significant role played by motivation in creative performances, and the diverse expression of creativity. Reasons for concern include the difficulty in tolerating in the classroom those traits associated with creative potential, such as nonconformity, independence, and persistent questioning.

1.6.6 CAI related research works on other variables

The findings offered in this summary resulted from a study of the 51 research reports cited in the References section. Each of these reports documents some relationship(s) between computer-based learning and student outcomes. These reports were concerned with the effects of one or more of the following types of educational computer use on student outcomes: CAI, CBE in general, the use of word processors for written composition, computer-managed instruction, programming, and simulations.

The effects of computer use on a large number of outcome areas were examined, including (a) academic achievement in general, (b) in mathematics, (c) in language arts, (d) in reading, (e) in science, (f) in problem-solving skills, and (g) in health and social studies.

1.6.6.1 Main findings

A. Microcomputer use and student achievement

The single best-supported finding in the research literature is that the use of CAI as a supplement to traditional, teacher-directed instruction produces achievement effects superior to those obtained with traditional
instruction alone. Generally speaking, this finding holds true for students of different ages and abilities and for learning in different curricular areas: Edwards, et al. Martin (1973); (1975); Grimes (1977); Ragosta, Rapaport and Savard (1980); Burns and Bozeman (1981); Holland, and Jamison (1982); Bangert-Drowns (1985); Bangert-Drowns, et al. (1985); Capper and Copple (1985); Kulik, Kulik, and Bangert-Drowns (1985); Mevarech and Rich (1985); Okey (1985); Batey (1986); Hawley, Fletcher, and Piele (1986); Rupe (1986); Bracey (1987); Ehman and Glen (1987); Kann (1987); Mokros and Tinker (1987); Horton, Lovitt, and Slocum (1988); Bahr and Rieth (1989); Gore, et al. (1989); Braun (1990).

Some writers also reported on research, which compared the effects of CAI alone with those produced by conventional instruction alone. Here, results are too mixed to permit any firm conclusion. Some inquires have found CAI superior, some have found conventional instruction superior, and still others have found no difference between them. Edwards, et al. (1975); Rapaport and Savard (1980); Capper and Copple (1985).

Other researchers and reviewers compared the achievement effects produced by all forms of computer based instruction (sometimes alone and sometimes as a supplement to traditional instruction) as compared with the effects of traditional instruction alone. While the research support is not as strong as that indicating the superiority of CAI, the evidence nevertheless indicates that CBE approaches as a whole produce higher achievement than traditional instruction by itself. Kulik, Bangert, and Williams (1983); Kulik (1983), (1985); Hasselbring (1984); Bangert-Drowns (1985); Bangert-Drowns, et al. (1985); Kulik and Kulik (1987); Roblyer, et al. (1988); Braun (1990).

This group of findings supports the conclusion drawn by Dalton and Hannafin (1988) in their study to the effect that “while both traditional and
computer-based delivery systems have valuable roles in supporting instruction, they are of greatest value when complementing one another”.

Researchers concerned with student writing outcomes have determined that writing performance is superior when the teaching approach emphasizes "writing as a process," rather than focusing only on the end product - the finished composition. The writing-as-a-process approach encourages students to engage in prewriting activities, followed by drafting, revising, editing, and final publication, with each step receiving considerable attention and often feedback from teachers or peer editors.

Word processing programs, with their capability to add, delete, and rearrange text, are seen as being far more congruent with the writing process than more laborious pencil-and-paper approaches. Moreover, most research in this area indicates that the use of word processors in writing programs leads to better writing outcomes than the use of paper-and-pencil or conventional typewriters. Specific positive outcomes associated with the use of word processors in writing include: Longer written samples – Greater variety of word usage – More variety of sentence structure – More accurate mechanics and spelling – More substantial revision – Greater responsiveness to teacher and peer feedback – Better understanding of the writing process – Better attitudes toward writing – Freedom from the problem of illegible handwriting. Collins and Sommers (1984); Sommer and Collins (1984); Batey (1986); Dickinson (1986); MacGregor (1986); Rodriguez and Rodriguez (1986); Bialo and Sivin (1990); Kinnaman (1990).

Researchers are careful to point out that these desirable outcomes are obtained when computers are used as part of a holistic, writing-as-a-process approach. Only using computers for drill and practice on isolated sub-skills, such as grammar and mechanics, is not associated with improved writing achievement. As expressed by Sommers and Collins
(1984) in their article on computers and writing, "microcomputers are counterproductive when used in a theoretical vacuum."

B. Learning rate

As well as enabling students to achieve at higher levels, researchers have also found that CAI enhances learning rate. Student learning rate is faster with CAI than with conventional instruction. In some research studies, the students learned the same amount of material in less time than the traditionally instructed students; in others, they learned more material in the same time. While most researchers don't specify how much faster CAI students learn, the work of Capper and Copple (1985) led them to the conclusion that CAI users sometimes learn as much as 40 percent faster than those receiving traditional, teacher-directed instruction. Edwards, et al. (1975); Grimes (1977); Rapaport and Savard (1980); Kulik (1983), Kulik, Bangert, and Williams (1983); Hasselbring (1984); (1985); Capper and Copple (1985); Batey (1986); Rupe (1986); Kulik and Kulik (1987).

C. Retention of learning

If students receiving CAI learn better and faster than students receiving conventional instruction alone, do they also retain their learning better? The answer, according to researchers who have conducted comparative studies of learning retention, is yes. In this research, student scores on delayed tests indicate that the retention of content learned using CAI is superior to retention following traditional instruction alone. Grimes (1977); Kulik, Bangert, and Williams (1983); Capper and Copple (1985); Kulik (1985); Kulik, Kulik, and Bangert-Drowsn (1985); Rupe (1986).

D. Attitude

Much of the research that examines the effects of CAI and other microcomputer applications on student learning outcomes also investigates effects upon student attitudes. This line of inquiry has brought most
researchers to the conclusion that the use of CAI leads to more positive student attitudes than the use of conventional instruction. This general finding has emerged from studies of the effects of CAI on student attitudes toward Computers and the use of computers in education. Hess and Tenezakis (1971); Kulik (1983), (1985); Kulik, Bangert, and Williams (1983); Hasselbring (1984); Batey (1986); Ehman and Glen (1987); Roblyer (1988).

More positive students' attitude towards Course content/subject matter by the use of CAI as compared to conventional instruction was reported by: Rapaport and Savard (1980); Batey (1986); Rodriguez and Rodriguez (1986); Ehman and Glen (1987); Dalton and Hannafin (1988); Roblyer, et al. (1988); Hounshell and Hill (1989); Braun (1990).

The use of CAI, yielded more positive attitude towards Quality of instruction compared to the conventional instruction; Kulik, Bangert, and Williams (1983); Rupe (1986); Kulik and Kulik (1987) and towards School in general; Batey (1986); Ehman and Glen (1987); Roblyer, et al. (1988); Bialo and Sivin (1990), and towards Self-as-learner. Mevarech and Rich (1985); Rupe (1986) Robertson, et al. (1987); Bialo and Sivin (1990).

1.6.6.2 Other beneficial effects

The effects of CAI on other student outcomes have not been as extensively researched as CAI's effects on achievement, learning rate, retention, and attitudes. Some researchers have, however, investigated CAI's influence on other variables and found it to confer benefits on:

(i) Locus of control. Capper and Copple (1985), Kinnaman (1990), and Louie (1985) found that CAI students have more of an internal locus of control/sense of self-efficacy than conventionally instructed students.

(ii) Attendance. CAI students had better attendance in Capper and Copple's study (1985), Rupe's review (1986), and the ISTE study (1990).
(iii) **Motivation/time-on-task.** Bialo and Sivin (1990) and Capper and Copple (1985) found that CAI students had higher rates of time-on-task than traditionally instructed controls.

(iv) **Cooperation/collaboration.** Cooperative, prosocial behavior was greater with CAI in the work of Dickinson (1986); Rupe (1986) and Mevarech, Stern, and Levita (1987).

1.6.6.3 **CAI and different student populations**

Is CAI more effective with some student populations than with others? Many researchers have conducted comparative analyses to answer this question and have produced findings in several areas.

Most comparative studies have shown that CAI is more beneficial for **younger students than for older ones.** While research shows CAI to be beneficial to students in general, the degree of impact decreases from the elementary to secondary to postsecondary levels. Hasselbring (1984); Kulik, Kulik, and Bangert-Drowns (1985); Okey (1985); Bangert-Drowns (1985); Bangert-Drowns, et al. (1985); Bracey (1987); Ehman and Glen (1987); Becker (1990).

Many comparisons show that CAI is more effective with **lower-achieving students than with higher-achieving ones.** Again, both lower- and higher-achieving students benefit from CAI. However, the comparatively greater benefits experienced by lower-achieving students, like those experienced by younger students, are largely due to the need these groups have for elements common to the majority of CAI programs--extensive drill and practice, privacy, and immediate feedback and reinforcement. Edwards, et al. (1975); Bangert-Drowns (1985); Bangert-Drowns, et al. (1985); Kulik, Kulik, and Bangert-Drowns (1985); Martin (1973); Okey (1985); Roblyer (1988); Kinnaman (1990).
Researchers note that CAI confers greater benefits on *economically disadvantaged students than those from more privileged backgrounds*. Lower SES students, too, benefit greatly from opportunities to interact privately with CAI drill-and-practice and tutorial programs. Ragosta, Holland, and Jamison (1982); Bangert-Drowns, et al. (1985); Mevarech and Rich (1985); Becker (1990).

Closely related to the above is the finding that CAI is more effective for teaching *lower-cognitive material than higher-cognitive material*. This research makes essentially the same point—that CAI is particularly effective for reinforcing the basic, fact-oriented learning most often engaged in by younger, lower-achieving, and/or lower SES students. Hasselbring (1984); Schmidt, et al. (1985-86); Ehman and Glen (1987).

Research conducted with *learning disabled, mentally retarded, hearing impaired, emotionally disturbed, and language disordered students* indicates that their achievement levels are greater with CAI than with conventional instruction alone. In some of this research, handicapped CAI students even outperformed conventionally taught, nonhandicapped students. Horton, Schmidt, et al. (1985-86); Lovitt, and Slocum (1988); Bahr and Rieth (1989); McLoughlin, and Bialozor (1989); Bialo and Sivin (1990).

The comparison of *Males versus females* was not addressed by enough researchers to draw firm conclusions. The 1988 meta-analysis of 82 studies of CBE conducted by Roblyer, et al. concluded that effect differences slightly favor boys over girls, with differences falling short of statistical significance.

1.6.6.4 *CAI and different curricular areas*

A few researchers undertook to compare the effectiveness of CAI in different curricular areas. Their findings, though not conclusive, indicate
that CAI activities are most effective in the areas of science and foreign languages, followed, in descending order of effectiveness, by activities in mathematics, reading, language arts, and English as a Second Language, with CAI activities in ESL found to be largely ineffective. Capper and Copple (1985); Kulik, Kulik, and Bangert-Drowns (1985), Roblyer, et al. (1988); Rodriguez and Rodriguez (1986).

1.6.6.5 Why students like CAI

An earlier section of this report offers research evidence showing that CAI enhances student attitudes toward several aspects of schooling. Some researchers took these investigations a step further by asking students what it is about CAI that they like. The following is a list of reasons given by students for liking CAI activities and/or favoring them over traditional learning. These student preferences also contribute to our understanding of why CAI enhances achievement.

Students say they like working with computers because computers:

- Are infinitely patient
- Never get tired, frustrated or angry
- Allow students to work privately
- Never forget to correct or praise
- Are fun and entertaining – Individualize learning
- Are self-paced
- Do not embarrass students who make mistakes
- Make it possible to experiment with different options
- Give immediate feedback
- Are more objective than teachers
- Free teachers for more meaningful contact with students – Are impartial to race or ethnicity
- Are great motivators
- Give a sense of control over learning
Are excellent for drill and practice
Call for using sight, hearing, and touch
Teach in small increments
Help students improve their spelling
Build proficiency in computer use, which will be valuable later in life
Eliminate the drudgery of doing certain learning activities by hand (e.g., drawing graphs)
Work rapidly closer to the rate of human thought. Lawton and Gerschner (1982); Rupe (1986); Mokros and Tinker (1987); Robertson, et al. (1987); Bialo and Sivin (1990); Braun (1990).

Many of these items point to students' appreciation of the immediate, objective, and positive feedback provided by computer learning activities by comparison with teacher-directed activities. As Robertson, et al. (1987) point out:
"This reduction in negative reinforcement allows the student to learn through trial and error at his or her own pace. Therefore, positive attitudes can be protected and enhanced".

1.6.6.6 Cost-effectiveness

While cost considerations are not a major focus of this report, it is worth noting that some of the research on effectiveness also addressed the cost-effectiveness of CAI and other computer applications. Ragosta, Holland, and Jamison (1982) concluded that equal amounts of time of CAI reinforcement and the more-expensive one-to-one tutoring produced equal achievement effects. Niemiec, Sikorski, and Walberg (1989) also found CAI activities significantly more cost-effective than tutoring and suggested that computers be used more extensively in schools. And in their 1986 study of costs, effects, and utility of CAI, Hawley, Fletcher, and Piele noted that the cost differences between CAI and traditional instruction were insignificant and concluded that "the microcomputer-assisted
instruction was the cost-effective alternative of choice" for both grades addressed in the study (p. 22).

1.7 Emergence of the problem

As it mentioned earlier, nowadays, schools are being requested to educate individuals who can think creatively and can find more suitable solutions to impelling complicated problems.

Schools have to adopt any useful devices, which may help to accomplishment of this purpose. Computers are the tools that can be provided for use in classrooms. In not keeping up with computer technology, education is failing to keep pace with the change-taking place in society as a whole. A computer has no value in itself. It has value depending on its way of application and on the purpose to which its users put it. The need for research on the way in which computers are used, therefore, is seriously felt if they are to meet the needs of today's students who will live their adult lives in the new century.

The educational system of IRAN is using computer technology. Beside offering some syllabus about computers, recently some software have been provided, by Bureau of Educational Technology to assist the teaching process, specially for teaching science subjects such as mathematics and Physics in high school level.

Although there are many research works dealing with effects of CAI on some variables like academic achievement, learning rate, learning retention, attitude, etc, but there are a few research works on the effectiveness of CAI regarding to creative thinking. Therefore, there is a lot to be done in this area with particular reference to the variables under study. Hence, the present study was undertaken,

This study intend to identify effective teaching strategies for teaching of high school Physics, by the study of effectiveness of CAI in
regard to motivating and extending of creativity. CAI software has been
designed to teach science. It is studied in relation to the three variables:
Socio-economic status, intelligence and attitude.

The content for the teaching science was based on the subject
"Physics" for 2nd grade students.

1.8 Statement of the problem

“Computer application in teaching Physics and its effect on general
and scientific creativity in relation to intelligence, SES and attitude towards
media.”

1.9 Delimitation of the study

The study delimited with respect to level, subject and the sample.
Only a segment of Physics course of the high school syllabus was taken for
the study. The study conducted on the classes of the boy and girls high
schools situated in the urban setting of Esfahan.

1.10 Objectives of the study

This study was designed to attain the following objectives:

• To select the segment of Physics for the experimental treatment and
  the package of software for teaching at the specified level.

• To study the effectiveness of the computer application as compared
to conventional teaching regarding general creativity, its
  components and scientific creativity.

• To study the effects of intelligence, attitude, and SES on general
  creativity, its components and scientific creativity.

• To study the two orders and higher order interactions among the
  factors under study.
1.11 Hypotheses

The study was designed to test the following 15 hypotheses for each of 6 sub variables of general creativity (i.e., figural fluency, figural flexibility, figural originality, verbal fluency, verbal flexibility, and verbal originality) and the same for total figural creativity, total verbal creativity, general and scientific creativity as dependent variables.

**Main effects**

$H_1$ Computer-assisted instruction (CIA) and conventional teaching method (CTM) yield different mean scores on each scale of creativity.

$H_2$ High and low intelligent groups attain different level of mean scores on each scale of creativity.

$H_3$ High positive and low positive attitudes produce different level of mean scores on each scale of creativity.

$H_4$ Upper and lower level SES groups attain different level of mean scores on each scale of creativity.

**Two order interactions**

$H_5$ The difference of the performance on each scale of creativity is affected by the interaction effect of teaching method and intelligence levels.

$H_6$ The difference of the performance on each scale of creativity, through CAI and CTM, is affected by levels of attitude.

$H_7$ The difference of the performance on each scale of creativity, through CAI and CTM, is affected by levels of S.E.

$H_8$ The performance scores on each scale of creativity attained by the two intelligence groups are affected by their attitude levels.

$H_9$ Intelligence and SES interact in respect of their performance on each scale of creativity.
H_{10} \quad \text{Attitude and SES interact in respect of their performance on each scale of creativity.}

**Three order interactions**

H_{11} \quad \text{Variables treatment, intelligence, and attitude interact in respect of their performance on each scale of creativity.}

H_{12} \quad \text{Variables treatment, intelligence, and SES interact in respect of their performance on each scale of creativity.}

H_{13} \quad \text{Variables treatment, attitude, and SES interact in respect of their performance on each scale of creativity.}

H_{14} \quad \text{Variables intelligence, attitude, and SES interact in respect of their performance on each scale of creativity.}

**Four order interaction**

H_{15} \quad \text{Variables treatment, intelligence, attitude, and SES interact in respect of their performance on each scale of creativity.}