CHAPTER- I

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Intelligence

Intelligence comes from the Latin verb "intellegere", which means "to understand". By this rationale, intelligence (as understanding) is arguably different from being "smart" (able to adapt to one's environment), or being "clever" (able to creatively adapt). By the Latin definition, intelligence arguably has to do with a deeper understanding of the relationships of all things around us; and with a capability for metaphysical manipulation of such objects once such understanding is mastered.

According to American Psychological Association, 1995:

Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought. Although these individual differences can be substantial, they are never entirely consistent: a given person's intellectual performance will vary on different occasions, in different domains, as judged by different criteria. Concepts of "intelligence" are attempts to clarify and organize this complex set of phenomena. Although considerable clarity has been achieved in some areas, no such conceptualization has yet answered all the important questions and none commands universal assent. Indeed, when two dozen prominent theorists were recently asked to define intelligence, they gave two dozen somewhat different definitions. (APA Task Force Report, 1995, Intelligence: Knowns and Unknowns)
According to Howard Gardner: "To my mind, a human intellectual competence must entail a set of skills of problem solving—enabling the individual to resolve genuine problems or difficulties that he or she encounters and, when appropriate, to create an effective product—and must also entail the potential for finding or creating problems—and thereby laying the groundwork for the acquisition of new knowledge."

Alfred Binet: "intelligence is the capacity to make judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one’s self to circumstances...auto-critique."

David Wechsler: "Intelligence can be regarded as the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment."

Linda Gottfredson: "Intelligence is the ability to deal with cognitive complexity."

Herrnstein and Murray: "Intelligence can be said as cognitive ability."

Sternberg and Salter: "Intelligence works as goal-directed adaptive behavior."

John Kotter on Leadership Intelligence: A "keen mind" i.e., strong analytical ability, good judgment, and the capacity to think strategically and multi-dimensionally.

D. Samuel Nuessle: "Intelligence is the mind’s ability to apply knowledge to a problem-solving situation."
A definition of intelligence comes from "Mainstream Science on Intelligence", which was signed by 52 intelligence researchers in 1994:

A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—"catching on", "making sense" of things, or "figuring out" what to do.

In an educational context, one's intelligence is not determined by one's academic performance or things other people have drummed into one's head. True intelligence is one's own knowledge acquired by one's interests, opinions and philosophies. A person's ability to think critically, analytically, rationally and open-mindedly is another key ingredient. And purposeful actions where common sense and good judgement are evident, reflects an intelligent individual. However, analytics skills only constitute one half of intelligence -- mimesis, synthesis, practical skills, imagination and the ability to create solutions to problems from scratch are equally important intelligence values.

**Intelligence in reference of Intelligence Testing**

Despite the variety of concepts of intelligence, the most influential approach to understanding intelligence (i.e., with the most supporters and the most published research over the longest period of
time) is based on psychometric testing. Such intelligence quotient (IQ) tests include the Stanford-Binet, Raven’s Progressive Matrices, the Wechsler Adult Intelligence Scale and the Wechsler-Bellevue.

All forms of IQ tests correlate highly with one another. The traditional view is that these tests measure g or "general intelligence factor". g can be derived as the principal factor using the mathematical method of factor analysis. However, psychometricians can also measure a wide range of abilities, which are distinct yet correlated. For example, g itself is sometimes considered to be a two part construct, gF and gC, which stand for fluid and crystallized intelligence.

One common view is that these abilities are hierarchically arranged with g at the vertex (or top, overlaying all other cognitive abilities). However, this is by no means universally accepted. Carroll (1993) and Snow (1984) put forward what might be described as an interpenetrating position having more in common with that of Charles Spearman (1924) who is credited with having developed the concept of g.

Intelligence, as measured by IQ and other aptitude tests, is widely used in educational, business, and military settings because it is an effective predictor of behavior. Intelligence is significantly correlated with successful training and performance outcomes. According to research by Ree and Earles (1992), g is the single best predictor of job performance, with minimal statistical improvements gained by the addition of more specific ability measures. Using data
from thousands of cases, they demonstrated that the average magnitude of correlation of $g$ with various criterion measures ranges from $r = .33$ to $.76$. [4]

In a recent review of the empirical research, David Geary found that $g$ factor is highly correlated with many important social outcomes. Individuals with low IQs are more likely to be divorced, more likely to have a child out of marriage, more likely to be incarcerated, and more likely to need long term welfare support. Furthermore, he found that high IQs are associated with more years of education, higher status jobs, and higher income.

IQ tests were originally devised specifically to predict educational achievement. The inventors of the IQ did not believe they were measuring fixed intelligence. Despite this, critics argue that intelligence tests have been used to support nativist theories in which intelligence is viewed as a qualitatively unique faculty with a relatively fixed quantity.

Critics of the psychometric approach point out that people in the general population have a somewhat different and broader conception of intelligence than what is measured in IQ tests. In turn, they argue that the psychometric approach measures only a part of what is commonly understood as intelligence. Furthermore, skeptics argue that even though tests of mental abilities are correlated, people still have unique strengths and weaknesses in specific areas. Consequently they argue that psychometric theorists over-emphasize $g$. 

Researchers in the field of human intelligence have encountered a considerable amount of public concern and criticism-- much more than scientists in other areas normally receive (Gottfredson, 2005). For example, a number of critics have challenged the relevance of psychometric intelligence in the context of everyday life. There have also been controversies over genetic factors in intelligence, particularly the question of whether these differences relate to race and gender (see Race and intelligence and Sex and intelligence). Another controversy in the field is how to interpret the increases in test scores that have occurred over time, the so-called Flynn effect.

Stephen Jay Gould was one of the most vocal critics of intelligence testing. In his book, The Mismeasure of Man, Gould argued that intelligence is not truly measurable, and also challenged the hereditarian viewpoint on intelligence. Many of Gould's criticisms were aimed at Arthur Jensen. Jensen responded that his work had been misrepresented. He further replied that making conclusions about modern IQ tests by criticizing the flaws of early intelligence research is like condemning the auto industry by criticizing the performance of the Model T.

**Theories of Intelligence**

The following are some of the major theories of intelligence that have emerged during the last 100 years.

**Charles Spearman - General Intelligence:**

British psychologist Charles Spearman (1863-1945) described a concept he referred to as general intelligence, or the g factor. After
using a technique known as factor analysis to examine a number of mental aptitude tests, Spearman concluded that scores on these tests were remarkably similar. People who performed well on one cognitive test tended to perform well on other tests, while those who scored badly on one test tended to score badly on other. He concluded that intelligence is general cognitive ability that could be measured and numerically expressed (Spearman, 1904).

**Louis L. Thurstone - Primary Mental Abilities:**

Psychologist Louis L. Thurstone (1887-1955) offered a differing theory of intelligence. Instead of viewing intelligence as a single, general ability, Thurstone’s theory focused on seven different "primary mental abilities" (Thurstone, 1938). The abilities that he described were:

- Verbal comprehension
- Reasoning
- Perceptual speed
- Numerical ability
- Word fluency
- Associative memory
- Spatial visualization

**Howard Gardner - Multiple Intelligences:**

One of the more recent ideas to emerge is Howard Gardner’s theory of multiple intelligences. Instead of focusing on the analysis of test scores, Gardner proposed that numerical expressions of human intelligence are not a full and accurate depiction of people’s abilities.
His theory describes eight distinct intelligences that are based on skills and abilities that are valued within different cultures.

The eight intelligences Gardner described are:

- Visual-spatial Intelligence
- Verbal-linguistic Intelligence
- Bodily-kinesthetic Intelligence
- Logical-mathematical Intelligence
- Interpersonal Intelligence
- Musical Intelligence
- Intrapersonal Intelligence
- Naturalistic Intelligence

**Robert Sternberg - Triarchic Theory of Intelligence:**

Psychologist Robert Sternberg defined intelligence as "mental activity directed toward purposive adaptation to, selection and shaping of, real-world environments relevant to one’s life" (Sternberg, 1985, p. 45). While he agreed with Gardner that intelligence is much broader than a single, general ability, he instead suggested some of Gardner’s intelligences are better viewed as individual talents. Sternberg proposed what he refers to as 'successful intelligence,' which is comprised of three different factors:

- Analytical intelligence: This component refers to problem-solving abilities.
- Creative intelligence: This aspect of intelligence involves the ability to deal with new situations using past experiences and current skills.
Practical intelligence: This element refers to the ability to adapt to a changing environment.

While there has been considerable debate over the exact nature of intelligence, no definitive conceptualization has emerged. Today, psychologists often account for the many different theoretical viewpoints when discussing intelligence and acknowledge that this debate is ongoing.

Type of Intelligence

Fluid vs. Crystallized Intelligence

Psychologist Raymond Cattell first proposed the concepts of fluid and crystallized intelligence and further developed the theory with John Horn. The Cattell-Horn theory of fluid and crystallized intelligence suggests that intelligence is composed of a number of different abilities that interact and work together to produce overall individual intelligence.

Fluid Intelligence

Cattell defined fluid intelligence as "...the ability to perceive relationships independent of previous specific practice or instruction concerning those relationships." Fluid intelligence is the ability to think and reason abstractly and solve problems. This ability is considered independent of learning, experience, and education. Examples of the use of fluid intelligence include solving puzzles and coming up with problem-solving strategies.

Crystallized Intelligence
Crystallized intelligence is learning from past experiences and learning. Situations that require crystallized intelligence include reading comprehension and vocabulary exams. This type of intelligence is based upon facts and rooted in experiences. This type of intelligence becomes stronger as we age and accumulate new knowledge and understanding.

**Fluid vs. Crystallized Intelligence**

According to Knox (1977), "... they constitute the global capacity to learn, reason and solve problems that most people refer to as intelligence. Fluid and crystallized intelligence are complementary in that some learning tasks can be mastered mainly by exercising either fluid or crystallized intelligence" (p. 420).

**Fluid and Crystallized Intelligence Throughout Life**

- Both types of intelligence increase throughout childhood and adolescence.
- Fluid intelligence peaks in adolescence and begins to decline progressively beginning around age 30 or 40.
- Crystallized intelligence continues to grow throughout adulthood.

**Multiple intelligences**

Dissatisfaction with traditional IQ tests has led to the development of a number of alternative theories, all of which suggest that intelligence is the result of a number of independent abilities that uniquely contribute to human performance. Most of these theories are relatively recent in origin, though it should be noted that Louis
Thurstone proposed a theory of multiple "primary abilities" in the early 20th Century.

Howard Gardner's Theory of multiple intelligences is based on studies not only on normal children and adults but also by studies of gifted individuals (including so-called 'savants'), of persons who have suffered brain damage, of experts and virtuosos, and of individuals from diverse cultures. This led Gardner to break intelligence down into at least eight different components: logical, linguistic, spatial, musical, kinesthetic, naturalist, intrapersonal and interpersonal intelligences. He argues that psychometric tests address only linguistic and logical plus some aspects of spatial intelligence; other forms have been entirely ignored. Moreover, the paper and-pencil format of most tests rules out many kinds of intelligent performance that matter in everyday life, such as giving an extemporaneous talk (linguistic) or being able to find one's way in a new town (spatial).

Robert Sternberg's Triarchic theory of intelligence proposes three fundamental aspects of intelligence-analytic, creative, and practical--of which only the first is measured to any significant extent by mainstream tests. His investigations suggest the need for a balance between analytic intelligence, on the one hand, and creative and especially practical intelligence on the other.

Daniel Goleman and several other researchers have developed the concept of Emotional intelligence and claim it is at least as important as more traditional sorts of intelligence. These theories grew from observations of human development and of brain injury victims.
who demonstrate an acute loss of a particular cognitive function -- e.g. the ability to think numerically, or the ability to understand written language -- without showing any loss in other cognitive areas.

IQ proponents have pointed out that IQ's predictive validity has been repeatedly demonstrated, for example in predicting important non-academic outcomes such as job performance, whereas the various multiple intelligence theories have little or no such support. Meanwhile, the relevance and even the existence of multiple intelligences have not been borne out when actually tested. Thus far, no one has been able to develop a set of ability tests that do not correlate together, and this refutes the claim that multiple intelligences are independent of each other.

Although humans have been the primary focus of intelligence researchers, scientists have also attempted to investigate animal intelligence, or more broadly, animal cognition. These researchers are interested in studying both mental ability in a particular species, and comparing abilities between species. They study various measures of problem solving, as well as mathematical and language abilities. Some challenges in this area are defining intelligence so that it means the same thing across species, and then operationalizing a measure that accurately compares mental ability across different species and contexts.

Wolfgang Köhler's pioneering research on the intelligence of apes is a classic example of research in this area.

**Emotional Intelligence**
Emotional intelligence (EI) refers to the ability to perceive, control and evaluate emotions. Some researchers suggest that emotional intelligence can be learned and strengthened, while others claim it is an inborn characteristic.

Since 1990, Peter Salovey and John D. Mayer have been the leading researchers on emotional intelligence. In their influential article "Emotional Intelligence," they defined emotional intelligence as, "the subset of social intelligence that involves the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions" (1990).

**The Four Branches of Emotional Intelligence**

Salovey and Mayer proposed a model that identified four different factors of emotional intelligence: the perception of emotion, the ability reason using emotions, the ability to understand emotion and the ability to manage emotions.

1. **Perceiving Emotions:** The first step in understanding emotions is to accurately perceive them. In many cases, this might involve understanding nonverbal signals such as body language and facial expressions.

2. **Reasoning With Emotions:** The next step involves using emotions to promote thinking and cognitive activity. Emotions help prioritize what we pay attention and react to; we respond emotionally to things that garner our attention.
3. **Understanding Emotions:** The emotions that we perceive can carry a wide variety of meanings. If someone is expressing angry emotions, the observer must interpret the cause of their anger and what it might mean. For example, if your boss is acting angry, it might mean that he is dissatisfied with your work; or it could be because he got a speeding ticket on his way to work that morning or that he's been fighting with his wife.

4. **Managing Emotions:** The ability to manage emotions effectively is a key part of emotional intelligence. Regulating emotions, responding appropriately and responding to the emotions of others are all important aspect of emotional management.

   According to Salovey and Mayer, the four branches of their model are, "arranged from more basic psychological processes to higher, more psychologically integrated processes. For example, the lowest level branch concerns the (relatively) simple abilities of perceiving and expressing emotion. In contrast, the highest level branch concerns the conscious, reflective regulation of emotion" (1997).

**A Brief History of Emotional Intelligence**

- **1930s** – Edward Thorndike describes the concept of "social intelligence" as the ability to get along with other people.
- **1940s** – David Wechsler suggests that affective components of intelligence may be essential to success in life.
- **1950s** – Humanistic psychologists such as Abraham Maslow describe how people can build emotional strength.
• 1975 - Howard Gardner publishes The Shattered Mind, which introduces the concept of multiple intelligences.

• 1985 - Wayne Payne introduces the term emotional intelligence in his doctoral dissertation entitled “A study of emotion: developing emotional intelligence; self-integration; relating to fear, pain and desire (theory, structure of reality, problem-solving, contraction/expansion, tuning in/coming out/letting go).”

• 1987 – In an article published in Mensa Magazine, Keith Beasley uses the term “emotional quotient.” It has been suggested that this is the first published use of the term, although Reuven Bar-On claims to have used the term in an unpublished version of his graduate thesis.

• 1990 – Psychologists Peter Salovey and John Mayer publish their landmark article, "Emotional Intelligence," in the journal Imagination, Cognition, and Personality.


**Measuring Emotional Intelligence**

• **Reuven Bar-On’s EQ-I**; A self-report test designed to measure competencies including awareness, stress tolerance, problem solving, and happiness. According to Bar-On, “Emotional intelligence is an array of noncognitive capabilities, competencies, and skills that influence one’s ability to succeed in coping with environmental demands and pressures.”
• **Multifactor Emotional Intelligence Scale (MEIS)**; An ability-based test in which test-takers perform tasks designed to assess their ability to perceive, identify, understand, and utilize emotions.

• **Seligman Attributional Style Questionnaire (SASQ)**; Originally designed as a screening test for the life insurance company Metropolitan Life, the SASQ measures optimism and pessimism.

• **Emotional Competence Inventory (ECI)**; Based on an older instrument known as the Self-Assessment Questionnaire, the ECI involves having people who know the individual offer ratings of that person’s abilities on a number of different emotional competencies.

### Factors Influence Intelligence

In addition to disagreements about the basic nature of intelligence, psychologists have spent a great amount of time and energy debating the various influences on individual intelligence. The debate focuses on one of the major questions in psychology: Which is more important - nature or nurture?

Today, nearly all psychologists recognize that both genetics and the environment play a role in determining intelligence. It now becomes a matter of determining exactly how much of an influence each factor has. First, it is important to note that genetics and environment interact to determine exactly how inherited genes are expressed. For example, if a person has tall parents, it is likely that the individual will
also grow to be tall. However, the exact height the person reaches can be influenced by environmental factors such as nutrition and disease.

**Evidence of genetic influences:**

- Twin studies suggest that identical twins IQ's are more similar than those of fraternal twins (Promin & Spinath, 2004).
- Siblings reared together in the same home have IQ's that are more similar than those of adopted children raised together in the same environment (McGue & others, 1993).

**Evidence of environmental influences:**

- Identical twins reared apart have IQ's that are less similar than identical twins reared in the same environment (McGue & others, 1993).
- School attendance has an impact on IQ scores (Ceci, 2001).
- Children who are breastfed during the first three to five months of life score higher on IQ tests at age 6 than same-age children who were not breastfed (Reinberg, 2008).

**Creativity**

The lexeme in the English word creativity comes from the Latin term creō "to create, make" and its derivational suffixes also come from Latin. The word "create" appears in English as early as the 14th century, notably in Chaucer (in The Parson's Tale). However, its modern meaning as an act of human creation did not emerge until after the Enlightenment.
Creativity refers to the phenomenon whereby a person creates something new (a product, a solution, a work of art, a novel, a joke, etc.) that has some kind of value. What counts as "new" may be in reference to the individual creator, or to the society or domain within which the novelty occurs. What counts as "valuable" is similarly defined in a variety of ways.

Scholarly interest in creativity ranges widely: Topics to which it is relevant include the relationship between creativity and general intelligence; the mental and neurological processes associated with creative activity; the relationship between personality type and creative ability; the relationship between creativity and mental health; the potential for fostering creativity through education and training, especially as augmented by technology; and the application of an individual's existing creative resources to improve the effectiveness of learning processes and of the teaching processes tailored to them.

Creativity and creative acts are therefore studied across several disciplines - psychology, cognitive science, education, philosophy (particularly philosophy of science), technology, theology, sociology, linguistics, business studies, and economics. As a result, there are a multitude of definitions and approaches.

**History of Creativity**

The way in which different societies have formulated the concept of creativity has changed throughout history, as has the term "creativity" itself.
The ancient Greeks, who believed that the muses were the source of all inspiration, actually had no terms corresponding to "to create" or "creator." The expression "poiein" ("to make") sufficed. The sole exception was poetry: the poet was seen as making new things — bringing to life a new world — while the artist merely imitated.

In Rome, this Greek view was modified, and Horace wrote that not only poets but painters were entitled to the privilege of daring whatever they wished. Unlike Greek, Latin had a term for "creating" ("creatio") and for "creator", and had two expressions for "to make" — "facere" and "creare".

Although neither the Greeks nor the Romans had any words that directly corresponded to the word creativity, their art, architecture, music, inventions, and discoveries provide numerous examples of what we would today describe as creative works. At the time, the concept of genius probably came closest to describing the creative talents bringing forth these works.

A fundamental change came in the Christian period: "creatio" came to designate God's act of "creation from nothing". "Creatio" thus took on a different meaning than "facere" ("to make"), and ceased to apply to human functions. The ancient view that art is not a domain of creativity persisted in this period.

Another shift occurred in more modern times. Renaissance men had a sense of their own independence, freedom and creativity, and sought to give voice to this sense of independence and creativity. Baltasar
Gracián (1601–1658) wrote: "Art is the completion of nature, as it were a second Creator...".

By the 18th century and the Age of Enlightenment, the concept of creativity was appearing more often in art theory, and was linked with the concept of imagination.

The Western view of creativity can be contrasted with the Eastern view. For the Hindus, Confucius, Taoists and Buddhists, creation was at most a kind of discovery or mimicry, and the idea of creation from "nothing" had no place in these philosophies and religions.

In the 19th century, not only was art regarded as creativity, but it alone was so regarded. When later, at the turn of the 20th century, there began to be discussion of creativity in the sciences (e.g., Jan Łukasiewicz, 1878–1956) and in nature (e.g., Henri Bergson), this was generally taken as the transference to the sciences of concepts proper to art.

In the late nineteenth and early twentieth centuries, leading mathematicians and scientists such as Hermann von Helmholtz (1896) and Henri Poincaré (1908) had begun to reflect on and publicly discuss their creative processes, and these insights were built on in early accounts of the creative process by pioneering theorists such as Graham Wallas (1926) and Max Wertheimer (1945).

However, the formal starting point for the scientific study of creativity, from the standpoint of orthodox psychological literature, is generally considered to have been J. P. Guilford’s 1950 address to the American Psychological Association, which helped popularize the topic and
focus on a scientific approach to conceptualising creativity and measuring it by means such as psychometric testing.

The etymological root of the word in English and most other European languages comes from the Latin creatus, literally "to have grown."

More than 60 different definitions of creativity can be found in the psychological literature. Perhaps the most widespread conception of creativity in the scholarly literature is that creativity is manifested in the production of a creative work (for example, a new work of art or a scientific hypothesis) that is both novel and useful.

Colloquial definitions of creativity are typically descriptive of activity that results:

- in producing or bringing about something partly or wholly new;
- in investing an existing object with new properties or characteristics;
- in imagining new possibilities that were not conceived of before;

and in seeing or performing something in a manner different from what was thought possible or normal previously.

"Creativity, it has been said, consists largely of re-arranging what we know in order to find out what we do not know." George Kneller

"The problem of creativity is beset with mysticism, confused definitions, value judgments, psychoanalytic admonitions, and the crushing weight of philosophical speculation dating from ancient times." Albert Rothenberg

Creativity (or creativeness) is a mental process involving the generation of new ideas or concepts, or new associations between existing ideas or concepts.
From a scientific point of view, the products of creative thought (sometimes referred to as divergent thought) are usually considered to have both originality and appropriateness. An alternative, more everyday conception of creativity is that it is simply the act of making something new.

Although intuitively a simple phenomenon, it is in fact quite complex. It has been studied from the perspectives of behavioural psychology, social psychology, psychometrics, cognitive science, artificial intelligence, philosophy, history, economics, design research, business, and management, among others. The studies have covered everyday creativity, exceptional creativity and even artificial creativity. Unlike many phenomena in science, there is no single, authoritative perspective or definition of creativity. Unlike many phenomena in psychology, there is no standardized measurement technique. Creativity has been attributed variously to divine intervention, cognitive processes, the social environment, personality traits, and chance ("accident", "serendipity"). It has been associated with genius, mental illness and humour. Some say it is a trait we are born with; others say it can be taught with the application of simple techniques. Although popularly associated with art and literature, it is also an essential part of innovation and invention and is important in professions such as business, economics, architecture, industrial design, science and engineering.

Despite, or perhaps because of, the ambiguity and multi-dimensional nature of creativity, entire industries have been spawned from the
pursuit of creative ideas and the development of creativity techniques. This mysterious phenomenon, though undeniably important and constantly visible, seems to lie tantalizingly beyond the grasp of scientific investigation.

Boden noted that it is important to distinguish between ideas which are psychologically creative (which are novel to the individual mind which had the idea), and those which are historically creative (which are novel with respect to the whole of human history). Drawing on ideas from artificial intelligence, she defines psychologically creative ideas as those which cannot be produced by the same set of generative rules as other, familiar ideas.

Often implied in the notion of creativity is a concomitant presence of inspiration, cognitive leaps, or intuitive insight as a part of creative thought and action. Pop psychology sometimes associates creativity with right or forehead brain activity or even specifically with lateral thinking.

Some students of creativity have emphasized an element of chance in the creative process. Linus Pauling, asked at a public lecture how one creates scientific theories, replied that one must endeavor to come up with many ideas — then discard the useless ones. Another adequate definition of creativity is that it is an "Assumptions breaking process". Many creative ideas are generated when somebody discards preconceived assumptions and decides on a new approach or method that might seem to others unthinkable.
Standard intelligence tests measure convergent thinking, which is the ability to come up with a single correct answer. However, creativity involves divergent thinking, which is the ability to come up with new and unusual answers.

Creativity is the ability to see something in a new way, to see and solve problems no one else may know exists, and to engage in mental and physical experiences that are new, unique, or different. Creativity is a critical aspect of a person's life, starting from inside the womb onward through adulthood.

Although many people equate creativity with intelligence, the two terms are not synonymous, and it is not necessary to have a genius-level IQ in order to be creative. While creative people do tend to have average or above-average scores on IQ tests, beyond an IQ of about 120 there is little correlation between intelligence and creativity. Researchers have found environment to be more important than heredity in influencing creativity, and a child's creativity can be either strongly encouraged or discouraged by early experiences at home and in school.

Creative individuals tend to share certain characteristics, including a tendency to be more impulsive or spontaneous than others. Nonconformity (not going along with the majority) can also be a sign of creativity. Many creative individuals are naturally unafraid of experimenting with new things; furthermore, creative people are often less susceptible to peer pressure, perhaps because they also tend to
be self-reliant and unafraid to voice their true feelings even if those go against conventional wisdom.

**Aspects of creativity**

Theories of creativity (in particular investigating why some people are more creative than others) have focused on a variety of aspects. The most dominant are usually identified as the four "Ps" - process, product, person and place. A focus on process is shown in cognitive approaches that try to describe thought mechanisms and techniques for creative thinking. Theories invoking divergent rather than convergent thinking (such as Guilford), or those describing the staging of the creative process (such as Wallas) are primarily theories of creative process. A focus on creative product usually appears in attempts to measure creativity in people (psychometrics, see below), or in creative ideas framed as successful memes. A focus on the nature of the creative person considers more general intellectual habits, such as openness, levels of ideation, autonomy, expertise, exploratory behaviour and so on. A focus on place considers the best circumstances in which creativity flourishes, including degrees of autonomy, access to resources and the nature of gatekeepers.

**Historical and personal creativity**

The product of "creativity" has typically been defined in one of two ways: either as something historically new (and relatively rare), such as scientific discoveries or great works of art; or as producing
something new in a personal sense - an apparent innovation for the creator, regardless of whether others have made similar innovations, or whether others value the particular act of creation. In the former sense there are writers such as Mihály Csíkszentmihályi have defined creativity in terms of rare individuals who have been judged by others to have made significant creative, often domain-changing contributions (and as such, the level of creativity of an individual can vary over historical time as perceptions change), and Simonton, who has analysed the career trajectories of the creatively eminent in order to map patterns and predictors of creative productivity. In the latter sense, writers such as Ken Robinson, and Anna Craft have focussed on creativity in a general population, particularly with respect to education.

There are a variety of labels for the two sides of this dichotomy. Margaret Boden distinguishes between h-creativity (historical) and p-creativity (personal). Craft makes a similar distinction between "high" and "little c" creativity. while Craft cites Robinson referring to "high" and "democratic" creativity. Common also is the pairing of terms "Big C" and "Little C".

Kozbelt, Beghetto and Runco, use a little-c/Big-C model to review major theories of creativity This approach was first introduced by James C. Kaufman and Beghetto into a four C model: mini-c (transformative learning), which are "personally meaningful interpretations of experiences, actions and insights"; little-c (everyday problem solving and creative expression); Pro-C, exhibited by people
who are professionally or vocationally creative but not eminent, and Big-C, reserved for those who are considered truly great in their field. This was to help distinguish more clearly between the amateur unapprenticed in the particular creative domain (e.g. the visual arts, astrophysics etc.), the professional who was domain-competent, and creative genius. The four-c model was also intended to help accommodate models and theories of creativity that stressed domain-competence as an essential component, and domain transformation as the highest mark of creativity; it also, they argued, made a useful framework for analysing creative processes in individuals.

**Creativity in psychology and cognitive science**

The study of the mental representations and processes underlying creative thought belongs to the domains of psychology and cognitive science.

**Graham Wallas**

Graham Wallas, in his work Art of Thought, published in 1926, presented one of the first models of the creative process. In the Wallas stage model, creative insights and illuminations may be explained by a process consisting of 5 stages:
(i) preparation (preparatory work on a problem that focuses the individual's mind on the problem and explores the problem's dimensions),

(ii) incubation (where the problem is internalized into the unconscious mind and nothing appears externally to be happening),

(iii) intimation (the creative person gets a "feeling" that a solution is on its way),

(iv) illumination or insight (where the creative idea bursts forth from its preconscious processing into conscious awareness); and

(v) verification (where the idea is consciously verified, elaborated, and then applied).

In numerous publications, Wallas' model is just treated as four stages, with "intimation" seen as a sub-stage. There has been some empirical research looking at whether, as the concept of "incubation" in Wallas' model implies, a period of interruption or rest from a problem may aid creative problem-solving. Ward lists various hypotheses that have been advanced to explain why incubation may aid creative problem-solving, and notes how some empirical evidence is consistent with the hypothesis that incubation aids creative problem-solving in that it enables "forgetting" of misleading clues. Absence of incubation may lead the problem solver to become fixated on inappropriate strategies of solving the problem. This work disputes the earlier hypothesis that creative solutions to problems arise mysteriously from the unconscious mind while the conscious mind is occupied on other tasks.
Wallas considered creativity to be a legacy of the evolutionary process, which allowed humans to quickly adapt to rapidly changing environments. Simonton provides an updated perspective on this view in his book, Origins of genius: Darwinian perspectives on creativity.

**J. P. Guilford**

Guilford performed important work in the field of creativity, drawing a distinction between convergent and divergent production (commonly renamed convergent and divergent thinking). Convergent thinking involves aiming for a single, correct solution to a problem, whereas divergent thinking involves creative generation of multiple answers to a set problem. Divergent thinking is sometimes used as a synonym for creativity in psychology literature. Other researchers have occasionally used the terms flexible thinking or fluid intelligence, which are roughly similar to (but not synonymous with) creativity.

**Arthur Koestler**

In The Act of Creation, Arthur Koestler lists three types of creative individual - the Artist, the Sage and the Jester.

Believers in this trinity hold all three elements necessary in business and can identify them all in "truly creative" companies as well. Koestler introduced the concept of bisociation—that creativity arises as a result of the intersection of two quite different frames of reference.
**Geneplore model**

In 1992, Finke et al. proposed the "Geneplore" model, in which creativity takes place in two phases: a generative phase, where an individual constructs mental representations called preinventive structures, and an exploratory phase where those structures are used to come up with creative ideas. Weisberg argued, by contrast, that creativity only involves ordinary cognitive processes yielding extraordinary results.

**The Explicit-Implicit Interaction (EII) theory**

Helie and Sun recently proposed a unified framework for understanding creativity in problem solving, namely the Explicit-Implicit Interaction (EII) theory of creativity. This new theory constitutes an attempt at providing a more unified explanation of relevant phenomena (in part by reinterpreting/integrating various fragmentary existing theories of incubation and insight). The EII theory relies mainly on five basic principles, namely 1) The co-existence of and the difference between explicit and implicit knowledge; 2) The simultaneous involvement of implicit and explicit processes in most tasks; 3) The redundant representation of explicit and implicit knowledge; 4) The integration of the results of explicit and implicit processing; and 5) The iterative (and possibly bidirectional) processing. A computational implementation of the theory was developed based on the CLARION cognitive architecture and used to simulate relevant human data. This work represents an initial step in
the development of process-based theories of creativity encompassing incubation, insight, and various other related phenomena.

**Conceptual blending**

In the '90s, various approaches in cognitive science that dealt with metaphor, analogy and structure mapping have been converging, and a new integrative approach to the study of creativity in science, art and humor has emerged under the label conceptual blending.

"Creativity is the ability to illustrate what is outside the box from within the box."
—The Ride

**Creativity and everyday imaginative thought**

In everyday thought, people often spontaneously imagine alternatives to reality when they think "if only...". Their counterfactual thinking is viewed as an example of everyday creative processes. It has been proposed that the creation of counterfactual alternatives to reality depends on similar cognitive processes to rational thought.

**Development of creativity**

*Infancy:* Scientific research in the late twentieth century revealed how the quality of interaction with unborn infants affects their later development of creative abilities. From birth to 18 months, infants can be encouraged to engage in creativity by playing with a variety of safe household materials, such as margarine tubs, empty boxes, and large
empty spools. Parents and caregivers can encourage experimentation by showing excitement and interest in what babies do. Parents can encouraged infants to develop creativity by singing to the infant and playing music, moving the infant’s hands to music, hanging a colorful mobile over the crib, placing pictures and photos where the baby can focus on them, and playing sound games with infants, such making up nonsense words or using rhyming words when talking to them.

**Toddlerhood;** From ages 18 months to four years, toddlers have progressively better hand and eye coordination. Caregivers should give them opportunities to develop this coordination by allowing them to draw with water-based paints, with chalk, and with crayons. Toddlers also can develop their creativity by pasting, tearing, cutting, printing, modeling with clay or play dough, or working with various materials to create collage, and for the older child, experimenting with fabric, tie dye, batik, printing, and simple woodwork.

From around 12 months, children may begin to imitate things that adults do. Real fantasy play begins at around ages 18 to 21 months. This should not prevent caregivers from playing imaginatively from a younger age, since fantasy play is linked to creativity. Studies have shown that children with very active fantasies tend to have personality traits that contribute to creativity—originality, spontaneity, verbal fluency, and a higher degree of flexibility in adapting to new situations. Children who fantasize a lot have unusually good inner resources for amusing themselves. Parents can
provide materials that lend themselves to fantasy play (dressing-up
clothes, dolls, housecleaning sets, and stuffed animals), play
pretending games with their children, and make suggestions and
encourage new ideas when toddlers play alone.

Adults should start involving toddlers with creative activities as soon
as they feel the child will enjoy them. Adults need to remember that
young toddlers are not skillful enough to consciously produce works of
art. At 18 months they may be more ready for creative play and even
at this age, they may spend no more than five minutes of
concentration on any one activity.

**Preschool;** Preschoolers can use the same materials as toddlers but
can use them in more complex ways. By age five, many children start
drawing recognizable objects. By age six, they are usually interested in
explaining their art works. They also like to tell stories and can make
books of their stories, including drawing pictures to accompany the
writing.

At this age fantasy play becomes more complex. Preschoolers
often direct each other on what to do or say as they play "Let's
pretend." Play is a critical part of developing creativity, according to
Mary Mindess, a child psychology professor at Lesley University in
Cambridge, Massachusetts. "Play allows children to construct
meaning for themselves," Mindess stated in an article in the August
2001 newsletter The Brown University Child and Adolescent Behavior
Letter. "Two children may share an experience, but each will process
the experience differently. Very often during play, children take things
they see in real life, or things they imagine they experience—like something they read in a book or saw on television—and make meaning of it," she wrote. As an example, she cites Mark Twain's stories about Tom Sawyer and Huckleberry Finn as good role-playing examples. "They include many examples of play," she wrote. "If, as in a scene in The Adventures of Tom Sawyer, a child pretends to be a riverboat captain, there's a lot more to that role-playing than simply knowing what a captain does and some basic boat terminology. There are feelings that accompany the role-playing: mainly, the power of being captain and the satisfaction in the ability to make decisions."

**School Age;** Early school-age children, six to nine years, incorporate lots of fantasy into their play, including action games with superheroes. Children of this age group spend much of their time daydreaming. Some daydreams become "real" as children begin to act them out in stories and plays.

Many researchers believe that in order to foster creativity in schools, education should be based on the discovery of knowledge and the development of critical attitudes, rather than on the passive absorption of knowledge. They believe this applies whether the class is in art, history, science, or humanities. However, most school teaching in the United States is based on the child's ability to memorize. The highest marks are often given to those who merely studied their lessons well. The pupil whose creative side is more developed may be considered a disruptive member of the class. For this reason some educators decided to encourage creativity outside the school system.
Science clubs are open to the young, in different countries, in which students can unleash their ideas and imagination. Student science fairs are also useful in developing creativity.

In the United States, children who participate in the nationwide invention contest organized by the Weekly Reader do not have to submit a model. A drawing or a photograph is sufficient to enter the contest, the purpose of which is to stimulate creative thinking among all the students in a class, all becoming involved in the process of invention either individually or in small groups. The class then chooses the best invention that will be presented later at the level of the national contest.

At ages nine to 12, children's creativity is greatly affected by peer influence. They increase the amount of detail and use of symbols in drawings. They also have expanded their individual creative differences and begin to develop their own set of creative values.

**Teenagers;** Teenagers are highly critical of the products they make and ideas they have. They try to express themselves creatively in a more adult-like way. Their creativity is influenced by their individual differences, physically, mentally, emotionally, and socially. In most high schools, classes that stress creativity, such as art, music, writing, and drama are electives and many may not be required. For many adolescents, high school is their last opportunity to take these creative classes.

Also, teens become more self-aware and self-conscious. This focus often causes them to conform to their peers, which stifles their
creativity and makes their thoughts less flexible. Flexibility refers to the ability to consider various alternatives at the same time.

**Factor affecting creativity:**

Rewards or incentives appear to interfere with creativity and reduce children's flexibility of thought. Studies show that any constraints such as structured instructions reduce creative flexibility in children. Many parents and teachers do not understand that children who are creative are often involved in imaginary play and are motivated by internal rather than external factors.

Environment appears to play a greater role than heredity in the development of creativity: identical twins reared apart show greater differences in creativity than in intellectual ability. Family environments with certain characteristics have been found to be more conducive to creativity than others. One of these characteristics is a relaxed parental attitude rather than one that is overly anxious or authoritarian. On the whole, the families of creative children discipline them without rigid restrictions, teaching them respect for values above rules. Similarly, they emphasize achievement rather than grades. The parents in such homes generally lead active, fulfilling lives themselves and have many interests. Finally, they reinforce creativity in their children by a general attitude of respect and confidence toward them and by actively encouraging creative pursuits and praising the results.

It has been found that creativity in both children and adults is affected by positive reinforcement.
Positive reinforcement has also been shown to boost fifth graders' scores on creativity tests, help sixth graders write more original stories, and lead college students to produce novel word associations. Studies have also found that positively reinforcing one kind of creative activity encourages original thinking in other areas as well.

Just as certain actions and attitudes on the part of parents can encourage creativity, others have been found to discourage it. Devising restrictive guidelines or instructions for an activity reduces its potential as a creative experience. Unrestricted, imaginative play is central to creativity in children—exposure to new objects and activities stimulates the senses, reinforces exploratory impulses, and results in the openness to new experiences and ideas that foster creative thinking. In addition, anything that takes the focus away from the creative act itself and toward something external to it can be damaging. For example, knowing that one's efforts are going to be evaluated tends to restrict the creative impulse, as does knowing of the possibility of a prize or other reward.

Schools as well as families can encourage creativity by offering children activities that give them an active role in their own learning, allow them freedom to explore within a loosely structured framework, and encourage them to participate in creative activities for the sheer enjoyment of it rather than for external rewards.
Several studies have shown relationships sometimes exist between creativity and mental illness, including depression, schizophrenia, and attention-deficit hyperactivity disorder (ADHD).

For decades, scientists have known that eminently creative individuals have a much higher rate of manic depression or bipolar disorder than does the general population. But few controlled studies have been done to build the link between mental illness and creativity. One study that does support such a link was presented at the 2002 annual meeting of the American Psychiatric Association by Stanford University researchers Connie Strong and Terence Ketter. Using personality and temperament tests, they found healthy artists to be more similar in personality to individuals with manic depression than to healthy people in the general population. While creativity itself is not a sign of mental illness, parents should be aware that there is a much higher degree of mental illness, especially depression and bipolar disorder, in creative children than in their less creative peers.

**Measuring creativity**

**Creativity quotient**

Several attempts have been made to develop a creativity quotient of an individual similar to the intelligence quotient (IQ), however these have been unsuccessful.
Psychometric approach

J. P. Guilford’s group, which pioneered the modern psychometric study of creativity, constructed several tests to measure creativity in 1967:

- Plot Titles, where participants are given the plot of a story and asked to write original titles.
- Quick Responses is a word-association test scored for uncommonness.
- Figure Concepts, where participants were given simple drawings of objects and individuals and asked to find qualities or features that are common by two or more drawings; these were scored for uncommonness.
- Unusual Uses is finding unusual uses for common everyday objects such as bricks.
- Remote Associations, where participants are asked to find a word between two given words (e.g. Hand _____ Call)
- Remote Consequences, where participants are asked to generate a list of consequences of unexpected events (e.g. loss of gravity)

Building on Guilford’s work, Torrance developed the Torrance Tests of Creative Thinking in 1966. They involved simple tests of divergent thinking and other problem-solving skills, which were scored on:

- Fluency – The total number of interpretable, meaningful and relevant ideas generated in response to the stimulus.
• Originality – The statistical rarity of the responses among the test subjects.

• Elaboration – The amount of detail in the responses.

The Creativity Achievement Questionnaire, a self-report test that measures creative achievement across 10 domains, was described in 2005 and shown to be reliable and valid when compared to other measures of creativity and to independent evaluation of creative output.[35]

Such tests, sometimes called Divergent Thinking (DT) tests have been both supported[36] and criticized.

**Social-personality approach**

Some researchers have taken a social-personality approach to the measurement of creativity. In these studies, personality traits such as independence of judgement, self-confidence, attraction to complexity, aesthetic orientation and risk-taking are used as measures of the creativity of individuals. Other researchers have related creativity to the trait, openness to experience.

As the research into the relationship between personality traits and creativity continues to grow, a more complete picture has developed. Within the framework of the Big Five model of personality some consistent traits have emerged.[39] Openness to experience has been shown to be consistently related to a whole host of different assessments of creativity. Among the other Big Five traits, research has demonstrated subtle differences between different domains of
creativity. A meta-analysis by Gregory Feist showed that artists tend to have higher levels of neuroticism and introversion, while scientists are more conscientious.

**Other approaches to measurement**

Howard Gruber insisted on a case-study approach that expresses the existential and unique quality of the creator. Creativity to Gruber was the product of purposeful work and this work could be described only as a confluence of forces in the specifics of the case.

**Neurobiology of creativity**

The neurobiology of creativity has been discussed by Fred Balzac in a 2006 review article. He writes that creative innovation requires "coactivation and communication between regions of the brain that ordinarily are not strongly connected". Highly creative people who excel at creative innovation tend to differ from others in three ways:

- They have a high level of specialized knowledge,
- They are capable of divergent thinking mediated by the frontal lobe,
- They are able to modulate neurotransmitters such as norepinephrine in their frontal lobe.

Thus, the frontal lobe appears to be the part of the cortex that is most important for creativity.
The article also explored the links between creativity and sleep, mood and addiction disorders, and depression.

In 2005, Alice Flaherty presented a three-factor model of the creative drive. Drawing from evidence in brain imaging, drug studies and lesion analysis, she described the creative drive as resulting from an interaction of the frontal lobes, the temporal lobes, and dopamine from the limbic system. The frontal lobes can be seen as responsible for idea generation, and the temporal lobes for idea editing and evaluation. Abnormalities in the frontal lobe (such as depression or anxiety) generally decrease creativity, while abnormalities in the temporal lobe often increase creativity. High activity in the temporal lobe typically inhibits activity in the frontal lobe, and vice versa. High dopamine levels increase general arousal and goal directed behaviors and reduce latent inhibition, and all three effects increase the drive to generate ideas.

**Working Memory and the Cerebellum**

Vandervert described how the brain’s frontal lobes and the cognitive functions of the cerebellum collaborate to produce creativity and innovation. Vandervert’s explanation rests on considerable evidence that all processes of working memory (responsible for processing all thought) are adaptively modeled by the cerebellum. The cerebellum (consisting of 100 billion neurons, which is more that the entirety of the rest of the brain is also widely known to adaptively model all bodily movement. The cerebellum’s adaptive models of working memory processing are then fed back to especially frontal
lobe working memory control processes, where creative and
innovative thoughts arise. (Apparently, creative insight or the “aha”
experience is then triggered in the temporal lobe.) According to
Vandervert, the details of creative adaptation begin in “forward”
cerebellar models which are anticipatory/exploratory controls for
movement and thought. These cerebellar processing and control
architectures have been termed Hierarchical Modular Selection and
Identification for Control (HMOSAIC). New, hierarchically arranged
levels of the cerebellar control architecture (HMOSAIC) develop as
mental mulling in working memory is extended over time. These new
levels of the control architecture are fed forward to the frontal lobes.
Since the cerebellum adaptively models all movement and all levels of
thought and emotion, Vandervert’s approach helps explain creativity
and innovation in sports, art, and music, the design of video games,
technology, mathematics and thought in general.

**REM sleep**

Creativity involves the forming of associative elements into new
combinations that are useful or meet some requirement. Sleep aids
this process. REM rather than NREM sleep appears to be
responsible.[59][60] This has been suggested to be due to changes in
cholinergic and noradrenergic neuromodulation that occurs during
REM sleep.[59] During this period of sleep, high levels of acetylcholine
in the hippocampus suppress feedback from the hippocampus to the
neocortex, and lower levels of acetylcholine and norepinephrine in the
neocortex encourage the spread of associational activity within
neocortical areas without control from the hippocampus. This is in contrast to waking consciousness, where higher levels of norepinephrine and acetylcholine inhibit recurrent connections in the neocortex. It is proposed that REM sleep would add creativity by allowing "neocortical structures to reorganize associative hierarchies, in which information from the hippocampus would be reinterpreted in relation to previous semantic representations or nodes."

**Creativity and affect**

Some theories suggest that creativity may be particularly susceptible to affective influence.

**Creativity and positive affect relations**

According to Alice Isen, positive affect has three primary effects on cognitive activity:

1. Positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association;
2. Positive affect leads to defocused attention and a more complex cognitive context, increasing the breadth of those elements that are treated as relevant to the problem;
3. Positive affect increases cognitive flexibility, increasing the probability that diverse cognitive elements will in fact become associated. Together, these processes lead positive affect to have a positive influence on creativity.

Barbara Fredrickson in her broaden-and-build model suggests that positive emotions such as joy and love broaden a person's
available repertoire of cognitions and actions, thus enhancing creativity.

According to these researchers, positive emotions increase the number of cognitive elements available for association (attention scope) and the number of elements that are relevant to the problem (cognitive scope).

Various meta-analyses, such as Matthijs et al. (2008) of 66 studies about creativity and affect support the link between creativity and positive affect.

**Creativity and negative affect relations**

On the other hand, some theorists have suggested that negative affect leads to greater creativity. A cornerstone of this perspective is empirical evidence of a relationship between affective illness and creativity. In a study of 1,005 prominent 20th century individuals from over 45 different professions, the University of Kentucky's Arnold Ludwig found a slight but significant correlation between depression and level of creative achievement. In addition, several systematic studies of highly creative individuals and their relatives have uncovered a higher incidence of affective disorders (primarily bipolar disorder and depression) than that found in the general population.

**Fostering creativity**

Daniel Pink, in his 2005 book A Whole New Mind, repeating arguments posed throughout the 20th century, argues that we are entering a new age where creativity is becoming increasingly
important. In this conceptual age, we will need to foster and encourage right-directed thinking (representing creativity and emotion) over left-directed thinking (representing logical, analytical thought). However, this simplification of 'right' versus 'left' brain thinking is not supported by the research data.

Nickerson provides a summary of the various creativity techniques that have been proposed. These include approaches that have been developed by both academia and industry:

1. Establishing purpose and intention
2. Building basic skills
3. Encouraging acquisitions of domain-specific knowledge
4. Stimulating and rewarding curiosity and exploration
5. Building motivation, especially internal motivation
6. Encouraging confidence and a willingness to take risks
7. Focusing on mastery and self-competition
8. Promoting supportable beliefs about creativity
9. Providing opportunities for choice and discovery
10. Developing self-management (metacognitive skills)
11. Teaching techniques and strategies for facilitating creative performance
12. Providing balance

Some see the conventional system of schooling as "stifling" of creativity and attempt (particularly in the pre-school/kindergarten and early school years) to provide a creativity-friendly, rich, imagination-fostering environment for young children. Researchers
have seen this as important because technology is advancing our society at an unprecedented rate and creative problem solving will be needed to cope with these challenges as they arise. In addition to helping with problem solving, creativity can also help students identify problems where others have failed to do so. See the Waldorf School as an example of an education program that promotes creative thought.

Promoting intrinsic motivation and problem solving are two areas where educators can foster creativity in students. Students are more creative when they see a task as intrinsically motivating, valued for its own sake. To promote creative thinking educators need to identify what motivates their students and structure teaching around it. Providing students with a choice of activities to complete allows them to become more intrinsically motivated and therefore creative in completing the tasks.

Teaching students to solve problems that do not have well defined answers is another way to foster their creativity. This is accomplished by allowing students to explore problems and redefine them, possibly drawing on knowledge that at first may seem unrelated to the problem in order to solve it.

Several different researchers have proposed methods of increasing the creativity of an individual. Such ideas range from the psychological-cognitive, such as Osborn-Parnes Creative Problem Solving Process, Synectics, Science-based creative thinking, Purdue Creative Thinking Program, and Edward de Bono's lateral thinking; to
the highly-structured, such as TRIZ (the Theory of Inventive Problem-Solving) and its variant Algorithm of Inventive Problem Solving (developed by the Russian scientist Genrich Altshuller), and Computer-Aided Morphological analysis.

**Understanding and enhancing the creative process with new technologies**

A simple but accurate review on this new Human-Computer Interactions (HCI) angle for promoting creativity has been written by Todd Lubart, an invitation full of creative ideas to develop further this new field.

Groupware and other Computer Supported Collaborative Work (CSCW) platforms are now the stage of Network Creativity on the web or on other private networks. These tools have made more obvious the existence of a more connective, cooperative and collective nature of creativity rather than the prevailing individual one. Creativity Research on Global Virtual Teams is showing that the creative process is affected by the national identities, cognitive and conative profiles, anonymous interactions at times and many other factors affecting the teams members, depending on the early or later stages of the cooperative creative process. They are also showing how NGO's cross-cultural virtual team's innovation in Africa would also benefit from the pooling of best global practices online. Such tools enhancing cooperative creativity may have a great impact on society and as such should be tested while they are built following the Motto: "Build the
Camera while shooting the film”. Some European FP7 scientific programs like Paradiso are answering a need for advanced experimentally-driven research including large scale experimentation test-beds to discover the technical, societal and economic implications of such groupware and collaborative tools to the Internet.

On the other hand, creativity research may one day be pooled with a computable metalanguage like IEML from the University of Ottawa Collective Intelligence Chair, Pierre Levy. It might be a good tool to provide an interdisciplinary definition and a rather unified theory of creativity. The creative processes being highly fuzzy, the programming of cooperative tools for creativity and innovation should be adaptive and flexible. Empirical Modelling seems to be a good choice for Humanities Computing.

If all the activity of the universe could be traced with appropriate captors, it is likely that one could see the creative nature of the universe to which humans are active contributors. After the web of documents, the Web of Things might shed some light on such a universal creative phenomenon which should not be restricted to humans. In order to trace and enhance cooperative and collective creativity, Metis Reflexive Global Virtual Team has worked for the last few years on the development of a Trace Composer at the intersection of personal experience and social knowledge.

Metis Reflexive Team has also identified a paradigm for the study of creativity to bridge European theory of "useless" and non-instrumentalized creativity, North American more pragmatic creativity
and Chinese culture stressing more creativity as a holistic process of continuity rather than radical change and originality. This paradigm is mostly based on the work of the German philosopher Hans Joas, one that emphasizes the creative character of human action. This model allows also for a more comprehensive theory of action. Joas elaborates some implications of his model for theories of social movements and social change. The connection between concepts like creation, innovation, production and expression is facilitated by the creativity of action as a metaphor but also as a scientific concept.

The Creativity and Cognition conference series, sponsored by the ACM and running since 1993, has been an important venue for publishing research on the intersection between technology and creativity. The conference now runs biennially, next taking place in 2011.

**Creativity and Intelligence**

There has been debate in the psychological literature about whether intelligence and creativity are part of the same process (the conjoint hypothesis) or represent distinct mental processes (the disjoint hypothesis). Evidence from attempts to look at correlations between intelligence and creativity from the 1950s onwards, by authors such as Barron, Guilford or Wallach and Kogan, regularly suggested that correlations between these concepts were low enough to justify treating them as distinct concepts.
Some researchers believe that creativity is the outcome of the same cognitive processes as intelligence, and is only judged as creativity in terms of its consequences, i.e. when the outcome of cognitive processes happens to produce something novel, a view which Perkins has termed the "nothing special" hypothesis.

A very popular model is what has come to be known as "the threshold hypothesis", proposed by Ellis Paul Torrance, which holds that a high degree of intelligence appears to be a necessary but not sufficient condition for high creativity. This means that, in a general sample, there will be a positive correlation between creativity and intelligence, but this correlation will not be found if only a sample of the most highly intelligent people are assessed. Research into the threshold hypothesis, however, has produced mixed results ranging from enthusiastic support to refutation and rejection.

An alternative perspective, Renzulli's three-rings hypothesis, as based on both intelligence and creativity. More on both the threshold hypothesis and Renzulli's work can be found in O'Hara and Sternberg.

Correlations between creativity tests and IQ tests vary in magnitude from study to study and depend on which tests are used. Some correlations are no smaller than correlations among creativity tests, so they do not provide strong evidence that IQ and creativity are distinct dimensions. The findings can be understood in terms of a so-called triangular correlation (also known as the threshold hypothesis): Individuals in the lower half of the IQ distribution lack the requisite cognitive capacity to create and hence necessarily exhibit low
creativity; individuals in the upper half of the IQ distribution have the requisite capacity but may or may not develop a disposition to create. Consequently, creativity and IQ are highly correlated at low IQ levels but weakly correlated at high IQ levels. Alternative interpretations of the relation between creativity and intelligence have been proposed, including that they are two aspects of the same ability, that they are unrelated, and that they are mutually exclusive.

**Work of Grady M. Towers on relation between intelligence and creativity**

It has been repeated again and again until it has passed into psychometric folklore that above a threshold IQ of about 120, there is no relationship between measured intelligence and creative accomplishment. This bit of common wisdom, like many other myths, is a misinterpretation of the facts and is only half true. The facts are these: that the correlation between IQ and creativity is a twisted pear correlation, and that in a classic twisted pear correlation there is no *systematic* relationship between individual measurements on one variable and *individual* measurement on a second variable above a given threshold. There is, however, a definite relationship between measured intelligence and creative accomplishment for *groups* of people. There is a definite, empirically-observable, optimum IQ for creative accomplishment in intellectually demanding fields, that lies well below the maximum IQ, but also well above the 120 IQ limit.

Anyone familiar with elementary statistics has been introduced to the Pearson product moment correlation coefficient. In most cases
he will also have been introduced to the scatter diagram. This is where score pairs are plotted on a graph. He will usually have been taught that score pairs almost always form an ellipse and that if the ellipse is narrow, the correlation is high, but if the ellipse is circular, the correlation is zero: i.e., there is no systematic relationship between variables. There is, however, a compromise between these two extremes. It is found when there is a systematic relationship between two variables below a threshold, and no systematic relationship is found above the threshold. Its scatter diagram is a union of an ellipse with a circle.

**Creativity as Ability:**

All individuals with healthy brains have some degree of creative potential, but individuals vary in how much novelty they in fact produce. Psychometric measures of creativity are based on the hypothesis that the ability to create is general across domains of activity (art, business, music, technology, etc.) and stable over time. This view implies that a person whose creativity is above average in one domain can be expected to be above average in other domains also.

The Remote Associations Test (RAT) developed by Sarnoff A. Mednick measures how easily a person can find a link between semantically different concepts. E. Paul Torrance's Tests of Creative Thinking (TTCT) measures divergent production, that is, how many different answers to a question a person can provide within a time
limit. For example, a person might be asked to propose alternative titles to a well-known movie. More recent tests developed by Robert J. Sternberg use complex test items from realistic contexts. Creativity tests correlate modestly with each other. Critics point out that there are no objective criteria for scoring the responses and that test performance might not be indicative of a creative mind.

**Creativity and mental health:**

A study by psychologist J. Philippe Rushton found creativity to correlate with intelligence and psychoticism. Another study found creativity to be greater in schizotypal than in either normal or schizophrenic individuals. While divergent thinking was associated with bilateral activation of the prefrontal cortex, schizotypal individuals were found to have much greater activation of their right prefrontal cortex. This study hypothesizes that such individuals are better at accessing both hemispheres, allowing them to make novel associations at a faster rate. In agreement with this hypothesis, ambidexterity is also associated with schizotypal and schizophrenic individuals.

Particularly strong links have been identified between creativity and mood disorders, particularly manic-depressive disorder (aka bipolar disorder) and depressive disorder (aka unipolar disorder). In Touched with Fire: Manic-Depressive Illness and the Artistic Temperament, Kay Redfield Jamison summarizes studies of mood-disorder rates in writers, poets and artists. She also explores research
that identifies mood disorders in such famous writers and artists as Ernest Hemingway (who shot himself after electroconvulsive treatment), Virginia Woolf (who drowned herself when she felt a depressive episode coming on), composer Robert Schumann (who died in a mental institution), and even the famed visual artist Michelangelo.

Today, creativity forms the core activity of a growing section of the global economy — the so-called "creative industries" — capitalistically generating (generally non-tangible) wealth through the creation and exploitation of intellectual property or through the provision of creative services. The Creative Industries Mapping Document 2001 provides an overview of the creative industries in the UK. The Creative professional workforce is becoming a more integral part of industrialized nations' economies.

Creative professions include writing, art, design, theater, television, radio, motion pictures, related crafts, as well as marketing, strategy, some aspects of scientific research and development, product development, some types of teaching and curriculum design, and more. Since many creative professionals (actors and writers, for example) are also employed in secondary professions, estimates of creative professionals are often inaccurate. By some estimates, approximately 10 million US workers are creative professionals; depending upon the depth and breadth of the definition, this estimate may be double.
Isaac Newton’s law of gravity is popularly attributed to a creative leap he experienced when observing a falling apple.

Creativity is also seen as being increasingly important in a variety of other professions. Architecture and industrial design are the fields most often associated with creativity, and more generally the fields of design and design research. These fields explicitly value creativity, and journals such as Design Studies have published many studies on creativity and creative problem solving.

Fields such as science and engineering have, by contrast, experienced a less explicit (but arguably no less important) relation to creativity. Simonton shows how some of the major scientific advances of the 20th century can be attributed to the creativity of individuals. This ability will also be seen as increasingly important for engineers in years to come.

Accounting has also been associated with creativity with the popular euphemism creative accounting. Although this term often implies unethical practices, Amabile has suggested that even this profession can benefit from the (ethical) application of creative thinking.

**Creativity and Education:**

It is not known to what extent an individual’s ability to create can be enhanced. The popular press produces a steady stream of books that advocate particular techniques and training programs; most have not been evaluated, so it is not known whether they work.
The small numbers of training techniques that have been evaluated systematically produce modest effects. It is possible that more effective training techniques exist but have yet to be invented. Most training programs implicitly assume that creativity is a general ability or process.

Although it is unclear whether the ability to create can be enhanced, there is consensus that the disposition to create can be suppressed. Creativity and discipline are not antithetical - creative individuals practice much and work hard - but extensive reliance on overly structured activities can thwart the impulse to create, with negative effects on students' well-being. Students with high ability will perform better than others in activities that require design, imagination, or invention, but participation in such activities encourages the disposition to create in students at any level of ability.

Creative individuals often elicit negative reactions from others by violating social norms and expectations. In a school setting, care should be taken to distinguish creative students from students who cause disturbances due to emotional or social problems. Creative students who find ways to engage others in their projects are likely to become outgoing and adopt leadership roles. Creative students who experience difficulties in this regard are likely to engage in individual projects. In short, high creativity is compatible with both social and individualistic life styles; either outcome is healthy.