Module III

CRITICAL THINKING & PROBLEM SOLVING

21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making, Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity, Critical thinking Vs Creative thinking, Functions of Left Brain & Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence.

Steps in problem solving: Problem Solving Techniques, Six Thinking Hats, Mind Mapping, Forced Connections. Analytical Thinking, Numeric, symbolic, and graphic reasoning. Scientific temperament and Logical thinking.

Module 3: Critical Thinking & Problem Solving

Questions

1. What is the need for Creativity in the 21st century?
2. What is the role of imagination and intuition in creativity?
3. Explain how experiences influence creativity
4. What are the sources of creativity?
5. What is lateral thinking?
6. Which are the ten long-standing myths about creative thinking
7. HOW DOES CREATIVE THOUGHT DIFFER FROM CRITICAL THOUGHT?
8. Make a comparison between critical and creative thinking
9. How the functions of Left Brain & Right brain are different?
10. Compare convergent and divergent thinking
11. What is critical reading?
12. Explain the term " Multiple intelligence"
13. What are the steps in problem solving?

14. HOW TO SOLVE PROBLEMS USING THE SIX THINKING HATS

15. What are the steps to make a mind map?

16. What is meant by the term “Forced connections”?

17. What are the steps in Problem solving?

18. What is meant by the term “Analytical thinking”?

19. What is meant by the term “Quantitative reasoning”

20. Discuss about Scientific temperament and Logical thinking

Module III : CRITICAL THINKING & PROBLEM SOLVING

3.1 Need for Creativity in the 21st century

Creativity is a higher order thinking skill (HOTS) and it is critical skill needed for the 21st Century. The world is rapidly changing and pushing towards a global existence which is more competitive, demanding and unpredictable. The past no longer holds true for the future. We need a different approach and cannot be afraid of doing things differently, which will require creativity. We need a generation who can solve problems and find new opportunities. We need creative thinkers. Creative thinking is an important life skill for the 21st Century that helps us cope, adapt and flourish in our personal lives, education, business, and for society as a whole .

3.1.1 Imagination

Imagination, not being limited to the acquisition of exact knowledge by the requirements of practical necessity is largely free from objective restraints. The ability to imagine one's self in another person's place is very important to social relations and understanding. Albert Einstein said, "Imagination ... is more important than knowledge. Knowledge is limited. Imagination encircles the world."

In various spheres, however, even imagination is in practice limited: thus a person whose imaginations do violence to the elementary laws of thought, or to the necessary principles of practical possibility, or to the reasonable probabilities of a given case is usually regarded by mental health professionals as insane.

The same limitations beset imagination in the field of scientific hypothesis. Progress in scientific research is due largely to provisional explanations which are developed by imagination, but such hypotheses must be framed in relation to previously ascertained facts and in accordance with the principles of the particular science.

Imagination is an experimental partition of the mind used to develop theories and ideas based on functions. Taking objects from real perceptions, the imagination uses complex IF-functions[citation needed] to develop new or revised ideas. This part of the mind is vital to developing better and easier ways to accomplish old and new tasks.

Regarding the volunteer effort, imagination can be classified as:

1.voluntary (the dream from the sleep, the daydream)

2.involuntary (the reproductive imagination, the creative imagination, the dream of perspective)

3.1.2 Intuition

Intuition is a popular topic in psychology these days, and generally refers to a brain process that gives people the ability to make decisions without the use of analytical reasoning, the researchers suggest. Despite widespread acceptance of this idea by psychologists and the public, scientists have lacked a reliable test to gather objective data on intuition and even prove its existence.

Intuition is knowing something instantly without reasoning. The word "intuition" comes from the Latin word intueri, which means to look within. Your own answers are continuously being revealed to you from inside yourself.

Intuition is the wisdom within you: when you know who's calling before you pick up the phone; when you take an immediate liking to someone after only briefly seeing them in a picture; and when you feel excited at the thought of a meeting that has not yet happened. When you listen to and trust your intuition, you begin to notice that it gently and beautifully points the way, and offers you the truth in every situation.

Every individual has his or her own way of intuiting information. When you pay attention to your intuition and practice using it, you will become fluent in its language and be able to understand its subtle messages.

3.1.3 How experiences influence creativity

A simple way to understand creative thinking is to consider it as the process of coming up with new ideas. The ideas don't have to be new for the world at large (that's a different process altogether), they just have to be new for you.

So when you have that moment of "eureka!" when you solve a problem, or when see something you overlooked before, that's you experiencing a creative insight. New ideas are the direct result of millions of neurons – the cells that carry and process electrochemical signals – in your brain suddenly connecting in a way that they weren't before. That's really it.

Those connections between neurons is an interesting part of creativity that is occasionally overlooked, though it is really the driving point of all creative thinking.

Between the hippocampus and cerebral cortex of your brain there are about 10 billion neurons alone. Those two sections make up the primary parts of your brain that deal with your knowledge about the world and memories, so they're crucial to creative thinking and idea interpretation. 10 billion neurons, millions and millions firing every second, to process ideas.

Here's the thing: neurons function in a way that is important to understand for anyone looking to be more creative (or more rational, or more analytical): the more certain neural connections are made, the stronger those connections become.

For example: if you practice doing crossword puzzles every morning for a year, the part of your brain – the neural connections – that deals with solving crossword puzzles are going to be strengthened and ultimately you're going to be a bit of a crossword puzzle–solving champ.

If you really want to be more creative, do creative things regularly. Solve puzzles, doodle, daydream, paint, play a musical instrument and makeup your own songs. But most importantly: do new things every day. Experience more things and you'll be more creative.

3.1.4 Sources of Creativity

Creativity is important in our everyday activities. It helps get out of the ordinary, of the routine. Creativity brings a spark to life and can make it more interesting and exciting. With the help of creativity we can come up with new ideas and approaches to different things, - thus, creativity is the main source of development and innovation. But why do some people get creative easily and naturally and for some people it is much harder to get out of the prescribed notions and the routine?

Our whole planet, the Earth is not only amazingly beautiful, - it's the ideal source of exploration. One can hardly find something so perfect and magnificent as our planet is. There are different ways of how we can explore our universe (and, of course, encourage the children to do so).

Remember how children at a certain age start asking questions starting with "why?" "Why is the sky blue? Why is there a day and night? Why is the snow white?" And so on. These are not as easy questions to answer as they might seem at first sight.

Never miss the opportunity to see and explore the stars and the moon on a night sky.. Besides, exploring the sky will significantly fuel your imagination. The same is true about underwater exploration. Get reliable underwater equipment and move on to a new adventure!

Always find the time for reading. Encourage children to read fairy-tales, read them yourself and never stop doing it when you are an adult. You can explore every genre in literature, from historical novels to philosophical ones, - and try to read the authors from different time periods. Via books we can learn how our ancestors lived, what they did in life and what problems faced. Books are also the largest source of knowledge and imagination.

Creativity can be developed via different methods and techniques, and you can find your unique procedures for its blooming, - just never forget to continue to fuel your imagination by exploring the wonders of the universe.

3.1.5 Lateral Thinking

Idea generation and problem solving technique in which new concepts are created by looking at things in novel ways. Whereas the logical ('vertical') thinking carries a chosen idea forward, the sideways ('lateral') thinking provokes fresh ideas or changes the frame of reference. And, while vertical thinking tries to overcome problems by meeting them head-on, lateral thinking tries to bypass them through a radically different approach. The term was coined by the Maltese-born UK psychologist Dr. Edward de Bono in his 1970 book 'Lateral Thinking.' Lateral thinking, is the ability to think creatively, or "outside the box" as it is sometimes referred to in business, to use your inspiration and imagination to solve problems by looking at them from unexpected perspectives. Lateral thinking involves discarding the obvious, leaving behind traditional modes of thought, and throwing away preconceptions.

Lateral Thinking Quiz

The following questions will test your ability to think laterally. If you get more than 50% of these right you're certainly strong on your lateral thinking skills (or maybe you're just good at quizzes!)

1. A graduate applying for pilot training with a major airline was asked what he would do if, after a long-haul flight to Sydney, he met the captain wearing a dress in the hotel bar. What would you do?
2. A man built a rectangular house, each side having a southern view. He spotted a bear. What colour was the bear?
3. If you were alone in a deserted house at night, and there was an oil lamp, a candle and firewood and you only have one match, which would you light first?
4. What can you put in a wooden box that would make it lighter? The more of them you put in the lighter it becomes, yet the box stays empty.
5. Which side of a cat contains the most hair?
6. The 60th and 62nd British Prime Ministers of the UK had the same mother and father, but were not brothers. How do you account for this?
7. How many birthdays does a typical woman have?
8. Why can't a man living in Canterbury be buried west of the River Stour?
9. Is it legal for a man to marry his widow's sister?
10. If you drove a coach leaving Canterbury with 35 passengers, dropped off 6 and picked up 2 at Faversham, picked up 9 more at Sittingbourne, dropped off 3 at Chatham, and then drove on to arrive in London 40 minutes later, what colour are the driver's eyes?

11. A woman lives on the tenth floor of a block of flats. Every morning she takes the lift down to the ground floor and goes to work. In the evening, she gets into the lift, and, if there is someone else in the lift she goes back to her floor directly. Otherwise, she goes to the eighth floor and walks up two flights of stairs to her flat. How do you explain this?
12. A window cleaner is cleaning the windows on the 25th floor of a skyscraper, when he slips and falls. He is not wearing a safety harness and nothing slows his fall, yet he suffered no injuries. Explain.
13. The band of stars across the night sky is called the "..... Way"?
14. Yogurt is made from fermented .....
15. What do cows drink?

Answers:

1. Offer to buy her a drink! The captain was of course a woman. Many airlines are now hot on equal opportunities and a candidate who had difficulty envisaging that an airline captain might be female would not go very far!
2. White. Only at the North Pole can all four walls be facing South.
3. The match!
4. Holes
5. The outside
6. Churchill was Prime Minister twice, from 1940 to 45 and from 1951 to 55.
7. One
8. Because he is still alive .
9. No - because he's dead.
10. The colour of your eyes.
11. The woman is of small stature and couldn't reach the upper lift buttons.
12. He was cleaning the inside of the windows.
13. Milky Way
14. Milk

15 Water. After the previous two questions, did you answer milk?

3.1.6 Myths of creativity

Most people think creativity is divinely-inspired, unpredictable and bestowed on only a lucky few. There are a lot of popular myths about business creativity, yet none of them have much scientific evidence.

These are the ten long-standing myths about creative thinking:

1. Eureka myth. New ideas sometimes seem to appear as a flash of insight. But research shows that such insights are actually the culminating result of prior hard work on a problem. This

thinking is then given time to incubate in the subconscious mind as we connect threads before the ideas pop out as new eureka-like innovations.

2. Breed myth. Many people believe creative ability is a trait inherent in one's heritage or genes. In fact, the evidence supports just the opposite. There is no such thing as a creative breed. People who have confidence in themselves and work the hardest on a problem are the ones most likely to come up with a creative solution.

3. Originality myth. There's a long-standing myth about intellectual property -- the idea that a creative idea is proprietary to the person who thought of it. But history and empirical research show more evidence that new ideas are actually combinations of older ideas and that sharing those helps generate more innovation.

4. Expert myth. Many companies rely on a technical expert or team of experts to generate a stream of creative ideas. Harder problems call for even more knowledgeable experts. Instead, research suggests that particularly tough problems often require the perspective of an outsider or someone not limited by the knowledge of why something can't be done.

5. Incentive myth. The expert myth often leads to another myth, which argues that bigger incentives, monetary or otherwise, will increase motivation and hence increase innovation productivity. Incentives can help, but often they do more harm than good, as people learn to game the system.

6. Lone Creator myth. This reflects our tendency to rewrite history to attribute breakthrough inventions and striking creative works to a sole person, ignoring supportive work and collaborative preliminary efforts. Creativity is often a team effort, and recent research into creative teams can help leaders build the perfect creative troupe.

7. Brainstorming myth. Many consultants today preach the concept of brainstorming, or spontaneous group discussions to explore every possible approach, no matter how far-out, to yield creative breakthroughs. Unfortunately, there is no evidence that just "throwing ideas around" consistently produces innovative breakthroughs.

8. Cohesive myth. Believers in this myth want everyone to get along and work happily together to foster innovations. That's why we see so many "zany" companies where employees play foosball and enjoy free lunches together. In fact, many of the most creative companies have found ways to structure dissent and conflict into their process to better push their employees' creative limits.

9. Constraints myth. Another popular notion is that constraints hinder our creativity and the most innovative results come from people who have "unlimited" resources. Research shows, however, that creativity loves constraints. Perhaps companies should do just the opposite -- intentionally apply limits to leverage the creative potential of their people.

10. Mousetrap myth. Others falsely believe that once we have a new idea, the work is done. But the world won't beat a path to our door or even find the door to an idea for a better mousetrap, unless we communicate it, market it and find the right customers. We all know of at least one "better mousetrap" that is still hidden.

3.2 HOW DOES CREATIVE THOUGHT DIFFER FROM CRITICAL THOUGHT?

The lack of an agreed definition for creative/innovative and critical thinking makes it difficult to articulate these skills as explicit learning objectives. Creative thinking, for example, is conceptualised differently across disciplines, i.e. it is often referred to as 'innovation' in education, 'entrepreneurship' in business, and 'problem solving' in mathematics, law and engineering. A further complication is the diverse way in which the relationship between critical and creative thinking can be conceptualised. For example some educators view them as divergent skills others as part of the same skill, who contend that creative thinking is one dimension of critical thinking), or as complementary skills that both encourage independent and student-centred learning . While there is no commonly shared definition of either term, definitions provide a good starting point for identifying the dimensions of each construct.

There is a comprehensive body of literature on critical and creative thought, and a diverse range of definitions

They are often compared as follows:

Creative thinking is divergent, critical thinking is convergent; whereas creative thinking tries to create something new, critical thinking seeks to assess worth or validity in something that exists; whereas creative thinking is carried on by violating accepted principles, critical thinking is carried on by applying accepted principles. Although creative and critical thinking may very well be different sides of the same coin they are not identical

Table 1 provides a conceptualization of critical and creative thinking along these lines.

3.2.1 Critical vs. creative thinking

CRITICAL THINKING	CREATIVE THINKING
Analytic	Generative
Convergent	Divergent
Vertical	Lateral

Probability	Possibility
Judgement	Suspended judgement
Hypothesis testing	Hypothesis forming
Objective	Subjective
Answer	An answer
Closed	Open-ended
Linear	Associative
Reasoning	Speculating
Logic	Intuition
Yes but	Yes and

Critical thinking

The ideal critical thinker is considered to be:

Habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit

Some other examples of definitions of critical thinking are as follows:

Critical thinking is the use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned and goal directed .

Critical thinking is a capacity to work with complex ideas whereby a person can make effective provision of evidence to justify a reasonable judgement...critical thinking can be seen as a form of learning, in that new knowledge, in the form of the judgement, is formed in the process .

Thinking...is any mental activity that helps formulate or solve a problem, make a decision, or fulfill a desire to understand; it is a searching for answers, a reaching for meaning .

Creative thinking

Divergent thinking by contrast, is the ability to generate new, varied and unique ideas. It involves the skills of flexibility, originality, fluency, elaboration, brainstorming, modification, imagery, associative thinking, attribute listing, metaphorical thinking, with the aim being to stimulate curiosity and promote divergence .

The terms creativity and creative thinking are often used interchangeably in the literature. They are interconnected in the sense that creative thinking is a process that contributes to, or assists in fostering creativity, however creative thinking can be viewed as part of a broader interaction of elements. Creative thinking, or creativity-relevant skills, as part of the process is that contributes to creativity (alongside domain-relevant skills and task-motivation). Thus creative thinking is often used to refer to the more cognitive and definable aspect of the creative process (i.e. skills).. Creative thinking is often associated with tools and techniques such as brainstorming, problem solving and 'lateral thinking' which will be discussed in other sections.

Some examples of definitions of creativity:

Creativity requires a balance among synthetic, analytic, and practical abilities

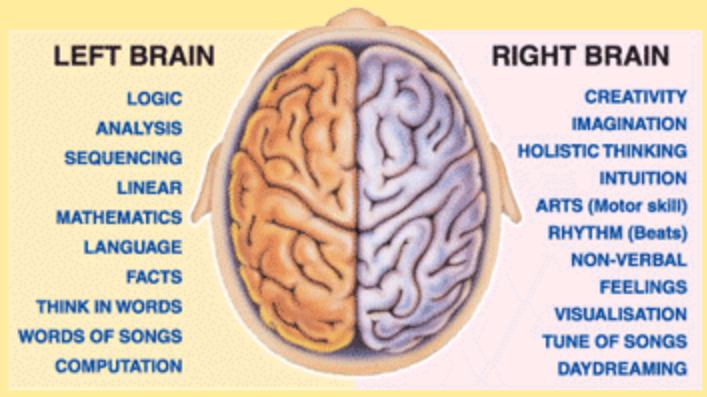
Creativity...involves departing from the facts, finding new ways, making unusual associations, or seeing unexpected solutions

The process of sensing difficulties, problems, gaps in information, missing elements, something askew; making guesses and formulating hypotheses about these deficiencies; evaluating and testing these guesses and hypotheses; possibly revising and retesting them; and, last, communicating the results

2.2.2 Functions of Left Brain & Right brain

Here's a quick overview of how the brain processes information.

Basic Characteristics of Left and Right brain:



In general, the left and right hemispheres of our brain process information in different ways. While we have a natural tendency towards one way of thinking, the two sides of our brain work together in our everyday lives. The right brain of the brain focuses on the visual, and processes information in an intuitive and simultaneous way, looking first at the whole picture then the details. The focus of the left brain is verbal, processing information in an analytical and sequential way, looking first at the pieces then putting them together to get the whole.

Left brain thinking is verbal and analytical. Right brain is non-verbal and intuitive, using pictures rather than words. The best illustration of this is to listen to people give directions. The left brain person will say something like "From here, go west three blocks and turn north on Vine Street. Go three or four miles and then turn east onto Broad Street."

Though right-brain or non-verbal thinking is often regarded as more 'creative', there is no right or wrong here; it is merely two different ways of thinking. One is not better than the other, just as being right-handed is not 'superior' to being left-handed. What is important is to be aware that there are different ways of thinking, and by knowing what your natural preference is, you can pay attention to your less dominant side to improve the same.

By learning abacus through the systematic training approach at UCMAS, children can fully realize their potential by activating both sides of their brain. By consciously using the right side of our brain, we can be more creative. More so , because left brain strategies are the ones used most often in the classroom, right brain students sometimes feel neglected. By activating the power of both hemispheres, a child will be able to retain knowledge better and become proficient in any subject, especially math.

Workings of Our Brain 

The human brain is made up of two halves. These halves are commonly called the right brain and left brain, but should more correctly be termed 'hemispheres'. For some reason, our right and left hemispheres control the 'opposite' side of our bodies, so the right hemisphere controls our left side and processes what we see in our left eye while the left hemisphere controls the right side and processes what our right eye sees.

The concept of right brain and left brain thinking developed from the research in the late 1960s of an American psychobiologist Roger W Sperry. He discovered that the human brain has two very different ways of thinking. One (the right brain) is visual and processes information in an intuitive and simultaneous way, looking first at the whole picture then the details. The other (the left brain) is verbal and processes information in an analytical and sequential way, looking first at the pieces then putting them together to get the whole. Sperry was awarded a Nobel Prize in 1981.

So as you know, the human brain consists of the right brain and the left brain. The shapes of these two parts are similar, but differences have been gradually found in their functions. The left brain is also referred to as the digital brain. It controls reading and writing, calculation, and logical thinking. The right brain is referred to as the analog brain. It controls three-dimensional sense, creativity, and artistic senses. These two work together, to allow us to function as humans.

3.2.3 Convergent & Divergent Thinking

When it comes to problem solving and idea generation, two ways are commonly cited, namely divergent and convergent thinking strategies. In an abundance of enthusiasm generated post-Sputnik 1, the convergent style of thinking was rapidly equated with typical intelligence. On the other hand, divergent thinking was equated with creativity and both were not uncommonly presented as competing or conflicting processes. While divergent thinking was considered to be good, its counterpart was seen as either bad or a necessarily evil considerably exaggerated in business and schools. Having said that, an important development in recent years is the increasing acceptance of the fact that real creative production needs both divergent thinking and convergent thinking, and not just the former.

From this sectionyou'll learn 1) what is divergent thinking? 2) what is convergent thinking? and so 3)which is better? divergent vs. convergent thinking for idea generation.

WHAT IS DIVERGENT THINKING?

The term "divergent thinking" refers to that strategy of solving problems characterized by the proposal of a multiplicity of possible solutions in an attempt to determine the one that works. It usually happens in a free-flowing, spontaneous manner, where multiple creative ideas are engendered and evaluated. A manifold number of potential solutions are studied in a brief span of time, and unconventional connections may be drawn. Once the stage of divergent thinking is complete, information and ideas are structured and organized using convergent thinking. Brainstorming and free writing are two processes that involve divergent thinking.

Divergence is typically signified by the capacity to produce many, or a greater number of complicated or complex ideas from a single idea or simple triggers or ideas. It calls for making unexpected combinations, changing information into unanticipated forms, identifying connections among remote associates, and the like. In divergent thinking, a single question returns multiple answers, and though the answers vary considerably depending on the person, all answers are of equal value.

Described below are eight elements of divergent thinking:

Complexity – The capacity to conceptualize difficult, multifaceted, many layered or intricate products or ideas;

Curiosity – The personality characteristic of displaying probing behaviors, searching, asking questions, learning to get more knowledge/information about something, and of being able to go deeper into ideas;

Elaboration – The skill of adding to, building off of or embellishing a product or an idea;

Flexibility – The capability of creating varied perceptions or categories wherefrom come a range of different ideas pertaining to the same thing or problem;

Fluency – The skill of engendering many ideas so as to have an increase in the number of potential solutions or associated products;

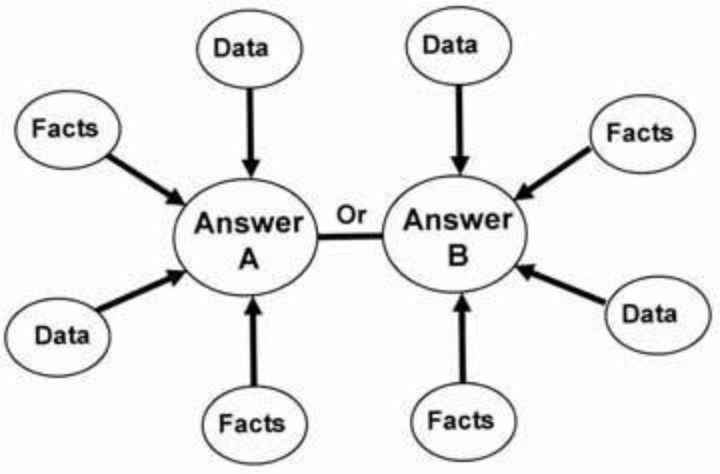
Imagination – The capability of dreaming up, inventing, or to think, to see, to conceptualize novel products or ideas, to be original;

Originality – The skill of coming up with fresh, unusual, unique, extremely different or completely new products or ideas;

Risk–taking – The readiness to be courageous, daring, adventuresome – take risks or experiment with new things so as to stand apart.

WHAT IS CONVERGENT THINKING?

Convergent thinking is a problem solving technique involving the bringing together different ideas from different participants or fields to determine a single best solution to a lucidly defined problem. In other words, this is a kind of thinking that concentrates on finding out the single best or frequently, correct solution to a problem or answer to a question. The credit for coining the term "convergent thinking" goes to Joy Paul Guilford. He came up with the term as an opposite term to "divergent thinking." The focus for this thinking strategy is speed, logic and accuracy and on identifying the known, reapplying techniques, and amassing stored information. This strategy is best suited for situations characterized by a readily available answer that just has to be worked out or recalled by way of decision-making strategies.



Standard IQ tests measure convergent thinking. Logic thought flow, pattern recognition, the capacity to solve problems and testing knowledge can all be evaluated and graded in these tests. Standardized multiple choice questions are also an example of testing convergent thinking.

DIVERGENT VS. CONVERGENT THINKING

Given below is a comparison of the two thinking styles with the factors of comparison being mood, creative ability, intellectual ability, brain activity, personality and sleep deprivation.

Mood – Research shows that gearing up for a creative thinking job can bring on mood swings determined by the kind of thinking utilized for the task. As per the research, convergent and divergent thinking affect mood in converse ways. While the former triggered a negative mood, the latter triggered the exact opposite – a positive mood.

Creative Ability – Creative ability was gauged in a study having both divergent and convergent tasks. In the case of the divergent tasks, though taken as a group, all the tasks showed a connection, they were not significant when studied between conditions.

The convergent thinkers accurately solved a greater number of the five remote associates problems compared to their counterpart divergent thinkers.

Intellectual ability – A sequence of standard intelligence tests was utilized to measure the divergent and convergent thinking capacities of adolescents.

Brain activity – Alterations in brain activity were assessed in subjects in the course of both divergent and convergent thinking. To achieve this, researchers analyzed the electroencephalography (EEG) patterns of participants in the course of divergent and convergent thinking.

Personality – Personality correlates pertaining to convergent and divergent thinking were studied. Results show that two personality characteristics namely Extraversion and Openness were seen to make possible divergent thinking.

Sleep deprivation – A 1988 study by J.A. Horne revealed that even a single night of sleep deprivation can cause significant impairment to divergent thinking. On the other hand, people engaged in convergent thinking tasks were seen to be more pliant with respect to short-term sleep loss.

Moving to everyday life, here's an example of convergent and divergent thinking in practice.

It is true that withstanding the earth's gravity to travel in space has been a dream that existed ever since women and men first cast their eyes on the stars. However, it was only in the mid-20th century that there was actually technology available to make the dream a reality.

Examples

Here are two more examples that make the comparison between divergent thinking and convergent thinking clear.

Divergent thinking: Mr. A's home is at a distance of five miles from work. His Chevrolet gets 30 MPG. However, he wishes to expend less fuel in his travel for both monetary and conservation-associated reasons. Money is not an issue. What choices does he have to cut his fuel consumption?

Convergent thinking: Mr. A's home is at a distance of five miles from work. His Chevrolet gets 30 MPG. However, he wishes to expend less fuel in his travel for both monetary and conservation-associated reasons. Money is not an issue. Which three vehicles are the best replacements for his car?

Both examples would result in important outcomes. The trigger for the convergent example could be some other problem – maybe his car was totaled, and he only had a weekend to find an answer to the problem.

3.2.4 Critical reading

Critical reading is a form of language analysis that does not take the given text at face value, but involves a deeper examination of the claims put forth as well as the supporting points and possible counterarguments. The ability to reinterpret and reconstruct for improved clarity and readability is also a component of critical reading. The identification of possible ambiguities and flaws in the author's reasoning, in addition to the ability to address them comprehensively, are essential to this process. Critical reading, much like academic writing, requires the linkage of evidential points to corresponding arguments.

There are no simple relations between these levels. As the "hermeneutic circle" demonstrates, the understanding of single words depends on the understanding of the text as a whole (as well as the culture in which the text is produced) and vice versa: You cannot understand a text if you do not understand the words in the text.

The critical reading of a given text thus implies a critical examination of the concepts used as well as of the soundness of the arguments and the value and relevance of the assumptions and the traditions on which the text is given.

"Reading between the lines" is the ability to uncover implicit messages and bias.

Goals of Critical Reading

Textbooks on critical reading commonly ask students to accomplish certain goals:

to recognize an author's purpose

to understand tone and persuasive elements

to recognize bias

Notice that none of these goals actually refers to something on the page. Each requires inferences from evidence within the text:

recognizing purpose involves inferring a basis for choices of content and language

recognizing tone and persuasive elements involves classifying the nature of language choices

recognizing bias involves classifying the nature of patterns of choice of content and language

Critical reading is not simply close and careful reading. To read critically, one must actively recognize and analyze evidence upon the page.

3.2.5 Multiple Intelligence

Many educators have had the experience of not being able to reach some students until presenting the information in a completely different way or providing new options for student expression. Perhaps it was a student who struggled with writing until the teacher provided the option to create a graphic story, which blossomed into a beautiful and complex narrative. Or maybe it was a student who just couldn't seem to grasp fractions, until he created them by separating oranges into slices.

Howard Gardner's Eight Intelligences

The theory of multiple intelligences challenges the idea of a single IQ, where human beings have one central "computer" where intelligence is housed. Howard Gardner, the Harvard professor who originally proposed the theory, says that there are multiple types of human intelligence, each representing different ways of processing information:

Verbal-linguistic intelligence refers to an individual's ability to analyze information and produce work that involves oral and written language, such as speeches, books, and emails.

Logical-mathematical intelligence describes the ability to develop equations and proofs, make calculations, and solve abstract problems.

Visual-spatial intelligence allows people to comprehend maps and other types of graphical information.

Musical intelligence enables individuals to produce and make meaning of different types of sound.

Naturalistic intelligence refers to the ability to identify and distinguish among different types of plants, animals, and weather formations found in the natural world.

Bodily-kinesthetic intelligence entails using one's own body to create products or solve problems.

Interpersonal intelligence reflects an ability to recognize and understand other people's moods, desires, motivations, and intentions.

Intrapersonal intelligence refers to people's ability to recognize and assess those same characteristics within themselves.

The Difference Between Multiple Intelligences and Learning Styles

One common misconception about multiple intelligences is that it means the same thing as learning styles. Instead, multiple intelligences represents different intellectual abilities. Learning styles, according to Howard Gardner, are the ways in which an individual approaches a range of tasks. They have been categorized in a number of different ways -- visual, auditory, and kinesthetic, impulsive and reflective, right brain and left brain, etc.

3.3 Steps in problem solving

Problem solving is the act of defining a problem; determining the cause of the problem; identifying, prioritizing and selecting alternatives for a solution; and implementing a solution. An organization needs to define some standard of problem solving, so that leadership can effectively direct others in the research and resolution of issues.

In problem solving, there are four basic steps.

1. Define the problem

Diagnose the situation so that your focus is on the problem, not just its symptoms. Helpful techniques at this stage include using flowcharts to identify the expected steps of a process and cause-and-effect diagrams to define and analyze root causes.

The chart below identifies key steps for defining problems. These steps support the involvement of interested parties, the use of factual information, comparison of expectations to reality and a focus on root causes of a problem. What's needed is to:

Review and document how processes currently work (who does what, with what information, using what tools, communicating with what organizations and individuals, in what time frame, using what format, etc).

Evaluate the possible impact of new tools and revised policies in the development of a model of "what should be."

2. Generate alternative solutions

Postpone the selection of one solution until several alternatives have been proposed. Having a standard with which to compare the characteristics of the final solution is not the same as defining the desired result. A standard allows us to evaluate the different intended results offered by alternatives. When you try to build toward desired results, it's very difficult to collect good information about the process.

Considering multiple alternatives can significantly enhance the value of your final solution. Once the team or individual has decided the "what should be" model, this target standard becomes the basis for developing a road map for investigating alternatives. Brainstorming and team problem-solving techniques are both useful tools in this stage of problem solving.

3. Evaluate and select an alternative

Skilled problem solvers use a series of considerations when selecting the best alternative. They consider the extent to which:

A particular alternative will solve the problem without causing other unanticipated problems.

All the individuals involved will accept the alternative.

Implementation of the alternative is likely.

The alternative fits within the organizational constraints.

4. Implement and follow up on the solution

Leaders may be called upon to order the solution to be implemented by others, "sell" the solution to others or facilitate the implementation by involving the efforts of others. The most effective approach, by far, has been to involve others in the implementation as a way of minimizing resistance to subsequent changes.

Feedback channels must be built into the implementation of the solution, to produce continuous monitoring and testing of actual events against expectations. Problem solving, and the techniques used to derive elucidation, can only be effective in an organization if the solution remains in place and is updated to respond to future changes.

1. Identifying The Problem

Before a problem can be solved, you must first recognize that a problem exists. Here is where your approach to problem-solving is crucial. You should not allow the problem to intimidate

you. You should approach it rationally and remind yourself that every problem is solvable if it is tackled appropriately.

Fear can block your ability to think clearly, but if you:

1. Follow a workable procedure for finding solutions;

2. Accept the fact that you can't foresee everything;

3. Assume that the solution you select is your best option at the time; and

4. Accept the possibility that things may change and your solution fail;

you will then enter the problem-solving process rationally, You should try to view it as an intellectual exercise. Once you recognize that a problem exists, your next step is to identify the problem.

First, you need to discover how the problem occurred. Ask yourself the following questions:

1. Did something go wrong?

2. Did something breakdown?

3. Were there unexpected results or outcome?

4. Is something that once worked no longer working?

Second, you need to know the nature of the problem:

1. Is it people, operational, technical, etc.?

2. Is it with a particular department, product or service, etc.?

3. Is it something tangible or intangible?

4. Is it an external or internal problem?

Third, you need to decide how significant the problem is.

Based on the level of significance, you may choose to deal with the problem or not to deal with it. Sometimes what you think is a small problem, when analyzed, proves to be a major problem. The reverse is also true. To determine this, you should ask yourself the following types of questions:

1. Is it disrupting operations?

2. Is it hampering sales?

3. Is it causing conflict among people?

4. Is it an everyday occurrence or is it infrequent?

5. Is it affecting personnel and their productivity?

6. Is it common or unusual?

7. Is it affecting goals, and if yes, which ones?

8. Is it affecting customers, vendors, and any other external people?

Fourth, you should narrow down the type of problem:

1. Is it basically a problem which occurred in the past and the main concern is to make certain that it doesn't occur again?

2. Is it a problem which currently exists and the main concern is to clear up the situation?

3. Is it a problem which might occur in the future and the basic concern is planning and taking action before the problem arises?

The answer to all of the above questions will help you focus on the true problem. You cannot effectively research the causes of a problem until you have a clear understanding of what the problem is. Sometimes, people spend many hours on what they perceive as a problem only to find out, after seeking the causes, that something else was really the problem.

After you've gathered the information and reviewed it, you will have a pretty clear understanding of the problem and what the major causes of the problem are. At this point, you can research the causes further through observation and additional interviewing. Now, you should summarize the problem as briefly as possible, list all the causes you have identified, and list all the areas the problem seems to be affecting.

Before proceeding to finding solutions, there is some additional research that could be done. If possible and if warranted, you might wish to find out:

1. What has previously been done in regards to this problem.

2. What have other companies done.

3. What formal knowledge might you need to acquire.

4. What has been learned from past experience.

5. What do experts say about the problem.

2. Roadblocks to Problem Solving

Many of us serve as our own roadblocks in solving problems. There are a variety of roadblocks to watch for in order to effectively use the technique of problem solving:

1. Watch out for old habits.

2. Check your perceptions.

3. Overcome your fears.

4. Be careful of assumptions.

5. Don't be tied to a problem; try to look at it with detachment.

6. Don't let yourself procrastinate.

7. Control your inclination for reactive solutions.

8. Control your inclination for rash solutions.

9. Avoid emotional responses and always attempt to be rational.

10. Be aware that the nature of a problem can change.

11. Do not skip steps in the problem solving process.

At this point, you are ready to check your understanding of the problem. You've already identified the problem, broken it all down into all its facets, narrowed it down, done research on it, and you are avoiding typical roadblocks. On a large pad, write down the problem, including all of the factors, the areas it affects, and what the effects are. For a better visual understanding, you may also wish to diagram the problem showing cause and effect.

Study what you have written down and/or diagrammed. Call in your employees and discuss your analysis with them. Based on their feedback, you may decide to revise. Once you think you fully understand the causes and effects of the problem, summarize the problem as succinctly and as simply as possible.

3. How to Find Solutions

There are a number of methods for finding solutions. We will describe five thinking methods below, but we recommend that you use a number of them in finding solutions. The first four methods described are unconventional and more innovative. They allow you the possibility of arriving at a novel solution. The fifth method is a more typical and straightforward method.

1**. Association:** There are three types of associative thinking. This type of thinking is basically a linking process either through similarity, difference, or contiguity. For example, contiguity finds

solutions from things that are connected through proximity, sequence, and cause and effect. The process works as follows: List as many parts of the problem you can think of. Then giving yourself a short time limit, list as many words or ideas that have either proximity, sequence, or related cause and effect to the ones you have listed. For example, a contiguous association might be "misplaced work - cluttered desk" (proximity); "misplaced work - rushing" (sequence); "misplaced work - irate customer" (cause and effect).

2. Analogy: This thinking method is a way of finding solutions through comparisons. The process is based on comparing the different facets of the problem with other problems that may or may not have similar facets. An analogy might go like this: "Employees have been coming in late to work quite often; how can I get them to be at work on time? This to me is like soldiers being late for a battle. Would soldiers come late to a battle? Why not?" By, comparing the situation of workers to the situation of soldiers, you may find a solution for a way to motivate employees to come to work on time.

3. Brainstorming: This thinking method is based on a free, non-threatening, anything goes atmosphere. You can brainstorm alone or with a group of people. Most often a group of people from diverse backgrounds is preferable. The process works like this: The problem is explained to the group and each member is encouraged to throw out as many ideas for solutions as he or she can think of no matter how ridiculous or far-fetched they may sound.

4. Intuition: This mode of thinking is based on hunches. It is not, as some think, irrational. Intuition or hunches are built on a strong foundation of facts and experiences that are buried somewhere in the subconscious. All the things you know and have experienced can lead you to believe that something might be true although you've never actually experienced that reality. Use your intuition as much as possible but check it against the reality of the situation.

5. Analytical Thinking: This thinking method is based on analysis. It is the most conventional and logical of all the methods and follows a step by step pattern.

a. Examine each cause of the problem. Then for each cause, based on your direct knowledge and experience, list the solutions that logically would seem to solve the problem.

b. Check the possible solutions you arrive at with the research you have compiled on how the problem was solved by others.

Using each thinking technique, search for solutions. Keep a running list of all of them, even the ones that seem far out, too simple, or even impossible. The effect of this is to give you a rich pool of ideas that will lead you to the best solution.

4. Sorting Out the Best Solution

Go through your long list of solutions and cross-out those that obviously won't work. Those ideas are not wasted for they impact on those ideas that remain. In other words, the best ideas

you select may be revised based on the ideas that wouldn't work. With the remaining solutions, use what is called the "Force Field Analysis Technique." This is basically an analysis technique which breaks the solution down into its positive effects and negative effects. To do this, write each solution you are considering on a separate piece of paper. Below the solution, draw a line vertically down the center of the paper. Label one column advantages and one column disadvantages.

Now, some more analytical thinking comes into play. Analyzing each facet of the solution and its effect on the problem, listing each of the advantages and disadvantages you can think of.

After you complete this process for each solution, select those solutions which have the most advantages. At this point, you should be considering only two or three. In order to select the most appropriate solution, you should check each solution against the following criteria:

Cost effectiveness;

Time constraints;

Availability of manpower, material, etc.;

Your own intuition.

Design a plan of action chart including all the details you need to consider to carry it out and when each phase should happen. Keep in mind, though, that the best plans have setbacks for any number of reasons - from a key person being out for illness to a supplier shipping material late. So remember that your dates are only target dates. Solutions and plans of action must be flexible. Expect some things to be revised.

6. Evaluating the Plan of Action

Before you implement the plan of action, you should analyze it to see if you've considered as many of the variables as possible. Some questions you might ask yourself are:

1. Is there adequate staff to carry it out?

2. Is the plan detailed yet simple enough for those affected to know what to expect and how to carry it out?

3. Will it embarrass anyone - manager, employee, customer, vendor, etc.?

4. Is the time frame realistic and feasible?

5. Are there special conditions which may have been overlooked?

6. Who should be informed?

7. Who should be involved?

8. Who should be responsible for each aspect and/or phase?

9. Is the plan of action cost effective?

10. Does the plan have a public relations component?

7. Obstacles You May Encounter

There are a number of obstacles you may encounter when you implement your plan of action. It is, therefore, advisable that you devise ways to overcome them. Try not to allow obstacles to prevent you from reaching your goals. Some obstacles to watch for are:

1. Not receiving material and/or equipment on time;

2. Other situations which might arise and deflect your attention from this problem;

3. Procrastination;

4. A power struggle among managers and/or employees;

5. Resistance to change - a natural human condition.

Resistance to change and company-wide acceptance is typically the biggest obstacle. The best way to overcome them is to build a public relations component into your plan of action. The key question to ask yourself is, "How will I get my people to support the solution and make it work?"

8. Simulating the Solution / Plan of Action

Before you implement the plan of action on a full scale, you should select a small group of managers and employees and role play the solution in the work setting. Observe the group as they carry out the solution and take note of:

1. How they carry out the solution;

2. Their reactions to the solution;

3. Their understanding of the solution;

4. The effectiveness of the tools they are using in carrying out the solution;

5. Their resistance to change and reverting back to the previous behaviors.

Based on what you observe, you may need to revise some of your plans.

9. Successful Implementation

To assure the successful implementation of your solution and plan of action, remember the following:

1. Prepare your staff well in advance;

2. Train your staff well in advance;

3. Order equipment, material, etc., well in advance;

4. If necessary, hire new staff and do so well in advance;

5. Use PR at every meeting and in memos as much as possible;

6. Evaluate the effects of each phase as it is implemented and make the necessary adjustments;

7. Attempt to remain flexible and open-minded.

Evaluating the Success of Your Solution

As each phase of your plan of action is implemented, you should ask yourself whether your goals were achieved, how well they were achieved, and did it work smoothly. To check your own perceptions of the results, get as much feedback as possible from your managers and from your employees. What you may think is working may not be working well in the eyes of your people. Always remember that they are one of your most valuable tools in successfully carrying out your solution.

3.3.2 HOW TO SOLVE PROBLEMS USING THE SIX THINKING HATS

Every problem contains within itself the seeds of its own solution.

There is a Purpose Behind Every Problem

When life suddenly throws us a curve ball, things can get rather overwhelming and ridiculously frustrating in the blink of an eye. Being unable to deal with these challenges puts us at a disadvantage and sabotages our growth and development.

What if our problems are simply there just to test our resolve, maturity and ability to think within an unforgiving world? I guess most people will never really see it that way. Instead they will simply frown upon unfortunate circumstances — seeing them as unlucky events that have no purpose or meaning. Yet the reality is, that the exact opposite is true.

Every problem you experience has a purpose and message for you. It's there to help you grow as a person; it's there to help you become more effective and efficient in your daily undertakings, and it's there to see you through to the next pebble stone along your journey towards success.

It has been said, that it's not what happens to us that matters, it is rather how we respond to what happens that makes all the difference.

Edward de Bono's Six Thinking Hat system will help you to take control of your life once and for all. Through practice and a systematic implementation of this process, you will never feel the need to give up searching for an ideal solution to your problems or circumstances.

Within the Six Thinking Hats system, we will first introduce you to the Blue Managerial hat whose primary role is to manage and direct the thinking process.

Next you will meet the White Neutral hat whose role is to collect facts, data, stats and concrete information that lay the groundwork and foundations for your thinking.

Afterwards you will shake hands with the Red Intuitive hat who will use its feelings of intuition to find appropriate solutions to the problems you face.

The fourth hat you will meet is the Black Pessimistic hat. The black hat is frowned upon because of it's negative approach. However, it is one of the most important hats as it will help you to better understand the pitfalls of your thinking.

Afterwards you will be introduced to the Black hat's opposite: the Yellow Optimistic hat. This hat's role is to logically present positive plans of action that will help you overcome the problems confronting your reality.

Finally, you will meet the Green Creative hat whose role is to bend the rules, to think outside-the-box and expand the possibilities of the improbable in unique ways. The Green hat will help you to come up with brilliant creative solutions — opening the doors to new opportunities and avenues of thinking.

This interpretation of the Six Thinking Hat system is specifically targeted towards the personal problem solver (not group oriented) who struggles with life's daily challenges. However, please keep in mind that each Thinking Hat can also be used in another context related to academics, life, career and business.

The key is to take these guidelines and proactively use them in ways that will best suit your predicament and circumstances.

How to Use the Six Thinking Hats

Now that you have a clear and comprehensive understanding of the Six Thinking Hat problem solving thought process, it is important to briefly point out how these hats integrate and work together to formulate solutions and new ideas.

The managerial blue hat (Director) progressively allocates thinking time to each of the six hats including itself. Often the order of thinking would transition in the following way:

Blue Hat: Defines and outlines the problem under question and guides the other hats through the thinking process.

White Hat: Collects all the facts, data and statistics relevant to the problem. It will then use this information to reach a set of possible logical neutral solutions.

Red Hat: Intuitively reflects on the solutions and selects the best course of action based on its feelings and hunches.

Black Hat: Pessimistically and realistically confronts the solutions pinpointing holes, dangers, flaws and inadequacies in the proposed plans.

Yellow Hat: Looks beyond the black hat's pessimism and brings to light logical optimistic ideas and plans of action that will help counteract these dangers.

Green Hat: Takes solutions and ideas brought forward by the yellow hat and enhances them in a creative, unique and original way that helps ensure that they succeed as planned.

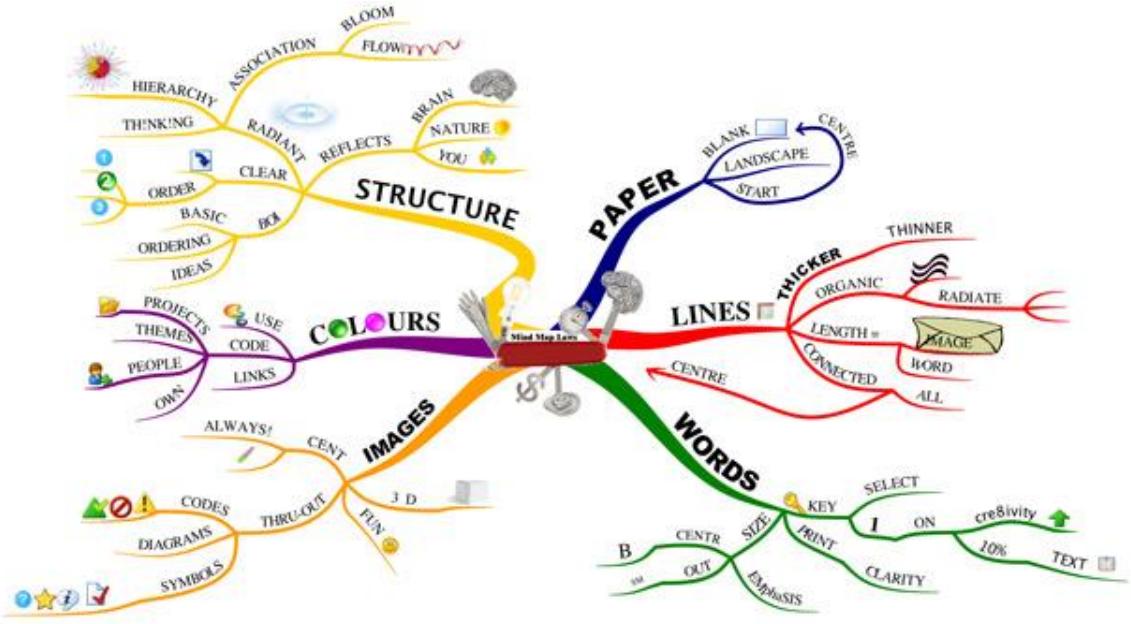
Blue Hat: After all hats have had their say, the blue hat continues to circulate between the hats in a logical way. It may for instance focus its attention on the red hat for further intuitive insights based on the green hat's creative ideas. Or it may ask the white hat to gather more facts and information about the dangers that the black hat brought to mind. After which it may ask the yellow hat to bring forth some logical positive solutions based on this new found knowledge and information.

No matter how the blue hat decides to synchronize the thinking process between the hats, it is important to remember that the blue hat is always seeking to obtain a global perspective and understanding of the problem — helping to bring to light the most ideal solution possible.

By being presently aware of this objective in your mind's-eye, will help you to cycle through the Six Thinking Hats more effectively.

3.3.3 Mind Mapping

What is a MindMap?



A Mind Map is a powerful graphic technique which provides a universal key to unlock the potential of the brain. It harnesses the full range of cortical skills – word, image, number, logic, rhythm, colour and spatial awareness – in a single, uniquely powerful manner. In so doing, it gives you the freedom to roam the infinite expanses of your brain. The Mind Map can be applied to every aspect of life where improved learning and clearer thinking will enhance human performance.

What do you need to make a Mind Map?

Because Mind Maps are so easy to do and so natural, the ingredients for your "Mind Map Recipe" are very few:

Blank unlined paper

Coloured pens and pencils

Your Brain

Your imagination!

When you use Mind Maps on a daily basis, you will find that your life becomes more productive, fulfilled, and successful on every level. There are no limits to the number of thoughts, ideas and connections that your brain can make, which means that there are no limits to the different ways you can use Mind Maps to help you.

7 Steps toMaking a Mind Map

Start in the CENTRE of a blank page turned sideways. Why? Because starting in the centre gives your Brain freedom to spread out in all directions and to express itself more freely and naturally.

Use an IMAGE or PICTURE for your central idea. Why? Because an image is worth a thousand words and helps you use your Imagination. A central image is more interesting, keeps you focussed, helps you concentrate, and gives your Brain more of a buzz!

Use COLOURS throughout. Why? Because colours are as exciting to your Brain as are images. Colour adds extra vibrancy and life to your Mind Map, adds tremendous energy to your Creative Thinking, and is fun!

CONNECT your MAIN BRANCHES to the central image and connect your second- and third-level branches to the first and second levels, etc. Why? Because your Brain works by association. It likes to link two (or three, or four) things together. If you connect the branches, you will understand and remember a lot more easily.

Make your branches CURVED rather than straight-lined. Why? Because having nothing but straight lines is boring to your Brain.

Use ONE KEY WORD PER LINE. Why Because single key words give your Mind Map more power and flexibility.

Use IMAGES throughout. Why Because each image, like the central image, is also worth a thousand words. So if you have only 10 images in your Mind Map, it's already the equal of 10,000 words of notes!

Originated in the late 1960s by Tony Buzan Mind Maps are now used by millions of people around the world – from the very young to the very old – whenever they wish to use their minds more effectively.

3.3.4 Forced Connections

As powerful as the traditional brainstorming is, it has a drawback: All the participants have a common understanding, a collective mind frame that traps them equally in the same box or comfort zone. They all think about the problem in the common terms, and as a result, the normal process of associations eventually becomes unproductive. This is when you need to switch to another Power Thinking technique: Forced Connections.

DEFINITION

Forced connections are based on the brain's ability to link two disparate items -such as words, objects , feelings, and ideas- and then use the new language generated by the linkages to think through the problem. It is called Forced Connections because it relies on random external triggers that force people to make a connection between the problem at hand and the trigger.

These triggers cause people to broaden their perspective.

APPLICATIONS

Triggers such as whimsical items (cards, toys, photos, etc.) might help to generate ideas by forcing an association between whatever objects they have chosen and the problem or situation they are working on. In this way an object introduces a new universe of potential cues from which to associate, spawning ideas that were not in the table before. Like brainstorming, forced connections are particularly useful when your group is blocked while trying to generate new ideas or to solve problems. In these circumstances it is usually imperative to introduce external triggers to get people thinking in new ways.

TECHNIQUES

There are several variations on the forced connection exercise. For example, you can hold a meeting with a bag filled with whimsical objects; or you can ask each participant in Round-robin fashion randomly to name an object; Don;t begin the connection process yet, simply write all objects down on an easel in front of the audience. Once everyone has named an object, repeat the round-robin, asking everyone to begin making connections and associations between the objects and the problem. Record the connections on the easel for all to see. If you want you can then ask for a second round of objects and repeat the process. This often adds a deeper level to the ideas generated. These variations will also increase the range of ideas on the problem solving table:

• Project a variety of pictures or photos on a screen or overhead projector.
• Ask each person to bring in an object.
• Open a dictionary to any page and pick out a word.

3.4 Problem Solving strategies

Problem Solving Strategies

- **Look for a pattern**
- **Make an organized list**
- **Guess and Check**
- **Make a table**
- **Work backwards**
- **Use logical reasoning**
- **Draw a diagram**
- **Solve a simpler problem**
- **Read the problem carefully**
- **Create problem solving journals**

Look for a pattern

Example: Find the sum of the first 100 even positive numbers.
Solution:

The sum of the first 1 even positive numbers is 2 or 1(1+1) = 1(2).
The sum of the first 2 even positive numbers is 2 + 4 = 6 or 2(2+1) = 2(3).
The sum of the first 3 even positive numbers is 2 + 4 + 6 = 12 or 3(3+1) = 3(4).
The sum of the first 4 even positive numbers is 2 + 4 + 6 + 8 = 20 or 4(4+1) = 4(5).

Look for a pattern:
The sum of the first 100 even positive numbers is 2 + 4 + 6 + ... = ? or 100(100+1) = 100(101) or 10,100.

Make an organized list

Example: Find the median of the following test scores: 73, 65, 82, 78, and 93.

Solution: Make a list from smallest to largest:
65
73
78 Since 78 is the middle number, the median is 78.
82
93

Guess and check

Example: Which of the numbers 4, 5, or 6 is a solution to (n + 3)(n - 2) = 36?

Solution: Substitute each number for "n" in the equation. Six is the solution since (6 + 3)(6 - 2) = 36.

Make a table

Example: How many diagonals does a 13-gon have?

Solution: Make a table:

Number of sides	Number of diagonals
3	0
4	2
5	5
6	9
7	14
8	20

Look for a pattern. Hint: If n is the number of sides, then n(n-3)/2 is the number of diagonals. Explain in words why this works. A 13-gon would have 13(13-3)/2 = 65 diagonals.

Work backwards

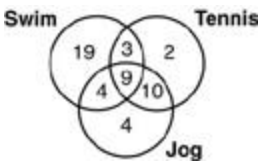
Example: Fortune Problem: a man died and left the following instructions for his fortune, half to his wife; 1/7 of what was left went to his son; 2/3 of what was left went to his butler; the man's pet pig got the remaining $2000. How much money did the man leave behind altogether?

Solution: The pig received $2000.
1/3 of ? = $2000
? = $6000
6/7 of ? = $6000
? = $7000
1/2 of ? = $7000
? = $14,000

Use logical reasoning

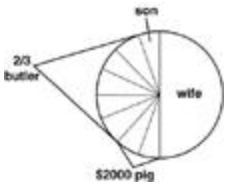
Example: At the Keep in Shape Club, 35 people swim, 24 play tennis, and 27 jog. Of these people, 12 swim and play tennis, 19 play tennis and jog, and 13 jog and swim. Nine people do all three activities. How many members are there altogether?

Solution: Hint: Draw a Venn Diagram with 3 intersecting circles.



Draw a diagram

Example: Fortune Problem: a man died and left the following instructions for his fortune, half to his wife; 1/7 of what was left went to his son; 2/3 of what was left went to his butler; the man's pet pig got the remaining $2000. How much money did the man leave behind altogether?



Solve a simpler problem

Example: In a delicatessen, it costs $2.49 for a half pound of sliced roast beef. The person behind the counter slices 0.53 pound. What should it cost?

Solution: Try a simpler problem. How much would you pay if a half pound of sliced roast beef costs $2 and the person slices 3 pounds? If a half pound costs $2, then one pound would cost 2 x $2 or $4. Multiply by the number of pounds needed to get the total: 3 x $4 = 12.
Now try the original problem: If a half pound costs $2.49, then one pound would cost 2 x $2.49 or $4.98. Multiply by the number of pounds needed to get the total: .53 x $4.98 = $2.6394 or $2.64.

Read the problem carefully

Know the meaning of all words and symbols in the problem.

Example: List the ten smallest positive composite numbers.

Solution: Since positive means greater than 0 and a composite number is a number with more than two whole number factors, the solution is 4, 6, 8, 9, 10, 12, 14, 15, 16, 18. For example, 4 has

three factors, 1, 2, and 4.

Sort out information that is not needed.

Example: Last year the Williams family joined a reading club. Mrs. Williams read 20 books. Their son Jed read 12 books. Their daughter Josie read 14 books and their daughter Julie read 7 books. How many books did the children of Mr. and Mrs. Williams read altogether?

Solution: You do not need to know how many books Mrs. Williams has read since the question is focusing on the children.

Determine if there is enough information to solve the problem.

Example: How many children do the Williams have?

Solution: There is not enough information to solve the problem. You do not know if Josie, Julie, and Jed are the only children.

Create problem solving journals

Students record written responses to open-ended items such as those tested on FCAT in mathematics. Student identifies problem solving strategies.

3.4.2 Analytical Thinking and quantitative reasoning expressed in written form, Numeric,

Analytical thinking is a critical component of visual thinking that gives one the ability to solve problems quickly and effectively. It involves a methodical step-by-step approach to thinking that allows you to break down complex problems into single and manageable components.

Analytical thinking involves the process of gathering relevant information and identifying key issues related to this information. This type of thinking also requires you to compare sets of data from different sources; identify possible cause and effect patterns, and draw appropriate conclusions from these datasets in order to arrive at appropriate solutions.

Analytical thinking can be broken down into three main steps:

Gather Information

Here you must gather all the necessary information that will be required to help you solve your problems. You also need to recognize whether you need to obtain more or higher quality information in order to collect all the relevant data you will need to arrive at an appropriate solution.

Gathering information requires that you ask appropriate questions of yourself and of others in order to gain the necessary insights that will enable you to make more effective decisions about

the problems you are facing. However, you also need to consider the relevance of your sources and the means by which you will gather this information.

Identify Issues and Problems

When it comes to analytical thinking, it's important to develop your ability to recognize underlying issues or problems based on trends, associations and cause-effect relationships between datasets.

Organize Information

Once all relevant information has been collected successfully, you must now organize and integrate all the pieces in a way that will provide you with insights and ideas that can be used to draw appropriate conclusions. This in turn will lay down the foundations for potential solutions to the problem or problems you are facing.

Analytical Thinking and Visual Thinking

Analytical thinking is very much integrated into the visual thinking framework, and especially into The Path. It's a part of the problem solving process you will utilize as you work visually towards acquiring the necessary insights that will help you achieve your goals and objectives.

Quantitative Thinking

By one definition, quantitative reasoning (QR) is the application of basic mathematics skills, such as algebra, to the analysis and interpretation of real-world quantitative information in the context of a discipline or an interdisciplinary problem to draw conclusions that are relevant to students in their daily lives. It is not just mathematics. Carleton College, for example, views QR as "the habit of mind to consider the power and limitations of quantitative evidence in the evaluation, construction, and communication of arguments in public, professional, and personal life." The term numeracy is also used in conjunction with these skills.

Ultimately, QR requires students to think critically and apply basic mathematics and statistics skills to interpret data, draw conclusions, and solve problems within a disciplinary or interdisciplinary context . Indeed, it requires the kind of mathematical and statistical skills that should be developed in high school, so all college students should have the basic skills required to achieve this broader, more ambitious college-level outcome. It is a competency of integration and application, both of which are intellectual capacities up near the top of the cognitive skills taxonomy originally described by Bloom . Assignments that develop QR can also elicit demonstration of achievement of other key outcomes like writing and/or oral communication as well as information literacy aspects. While many espouse the importance of QR, higher education faculty and administrators need to expand the ways we provide students with learning opportunities to understand and practice this set of skills.

Steps in Quantitative Reasoning

Communicate mathematical information symbolically, visually, numerically, and verbally.

Use arithmetical, algebraic, and geometric methods to solve problems.

Estimate and check answers to mathematical problems in order to determine reasonableness.

Solve word problems using quantitative techniques and interpret the results.

Apply mathematical/statistical techniques and logical reasoning to produce predictions, identify optima, and make inferences based on a given set of data or quantitative information.

Judge the soundness and accuracy of conclusions derived from quantitative information, recognizing that mathematical and statistical methods have limits and discriminating between association and causation.

Solve multistep problems.

Apply statistics to evaluate claims and current literature.

Demonstrate an understanding of the fundamental issues of statistical inference, including measurement and sampling.

Symbolic and graphic reasoning

People can be taught to manipulate symbols according to formal mathematical and logical rules. Cognitive scientists have traditionally viewed this capacity—the capacity for symbolic reasoning—as grounded in the ability to internally represent numbers, logical relationships, and mathematical rules in an abstract, a modal fashion. We present an alternative view, portraying symbolic reasoning as a special kind of embodied reasoning in which arithmetic and logical formulae, externally represented as notations, serve as targets for powerful perceptual and sensorimotor systems. Although symbolic reasoning often conforms to abstract mathematical principles, it is typically implemented by perceptual and sensorimotor engagement with concrete environmental structures.

3.4.3 Scientific temperament and Logical thinking

Scientific temperament

There is a huge discussion around scientific temperament in India. A section of intellectuals believes that scientific temperament is declining in the current scenario. They believe that it is happening because some powers are promoting religious dogmas radically. For them, promoting a scientific temperament is a necessity in India. Duties of Indian citizens, which also include the duty to develop a scientific temper. But, these people will never tell you what exactly scientific temper is. They will never release a single profound document on scientific temperament, which

can perhaps define what it means. But, for our convenience, we can assume that it probably is an extension of scientific methods in our daily lives. The problem starts right here. When we use the term 'scientific method', it comes with a certain criterion, like seeking a reason and proof for any belief. And where there is 'scientific method', there is no space for faith.

Faith and scientific method are incompatible. But, when we question if scientific temper destroys people's beliefs and takes away their faith, the classical answer is that scientific temperament, in fact, is not against faith but a tool to eradicate all kinds of superstitions from the society. But the question remains, how would you differentiate between faith and superstition. What we might consider superstition, might be faith for someone else.

So what I want to say is, that we do not need to make scientific temperament a necessity for our ordinary citizens. We need to promote the understanding of humanity as well. For this, we need better civic education. We need not promote scientific methods, but we need to promote civic values.

Logical thinking

Logical thinking is the rational cognitive process of reflecting objective reality actively with the help of concepts, judgments, reasoning and other forms of thinking. Through abstraction and analysis and thinking about the sensual materials, and the thinking process of discarding the dross and selecting the essential, eliminating the false and retaining the true, getting from one to the other, getting from the outside to the inside, logical thinking requires us to put the specific image and individual properties of things aside, reveal the properties and nature of things, form concepts and use them to judge and reason to reflect the objective reality generally and indirectly. Revealing the nature of things through abstractive gives it the features of consciousness, process, and necessity. The basic forms of logical thinking include concepts, judgments and reasoning. Logical thinking ways mainly include induction and deduction, analysis and synthesis, as well as from the abstract to the concrete and so on.

There are differences between the two concepts of logical thinking and the logical way of thinking.

The feature of logical thinking is that it is first based on the 'should-be' point; from this perspective it begins to establish a viewpoint, then propose illustrations, and then on the basis of illustrations begins to argue that the viewpoint is correct or to extract the viewpoint from tremendous arguments, and finally draws the logical and normative conclusion with induction and deduction. It is a thinking way in which the brain, with respect to the targeted objects, conducts induction, summary, abstract, and reasoning – an ordered thinking method of inductive reasoning. This thinking way presents the advantage of normatively and easy understanding.