

# Research Methodology in CSE, MTech-I (1<sup>st</sup> semester)

## Chapter 3: Approaches for Problem Solving

October 24, 2022



Devesh C Jinwala,

Professor in CSE, SVNIT, Surat and Adjunct Professor, IITJammu & Dean (R&C), SVNIT  
Department of Computer Science and Engineering, SVNIT, Surat

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- **Reviewing the research process as an eight step model:** How Problem Solving Skills fit in these steps? Problem Solving strategies prerequisites

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- **Constructing hypotheses:** The definition of a hypothesis. The functions of a hypothesis. The testing of a hypothesis. The characteristics of a hypothesis. Types of hypothesis.

[DCJ: 4 hours ?]

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Where does *Problem Solving Skills* fit in these steps?

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According to Kerlinger (1986: 17)

'If one wants to solve a problem, one must generally know what the problem is. It can be said that a large part of the problem lies in knowing what one is trying to do.'

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  - the validity of the associations or causation established
- is entirely dependent upon it.
- Hence the famous saying about computers, 'garbage in, garbage out', is equally applicable to research problems.

# *Problem Solving Strategies*

The problem solving strategies consist of the following

- Logical thinking



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- Representation

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- Logical thinking
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- Division into sub-problems

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- Logical thinking
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- Division into sub-problems
- Stretching to the extreme

- Reading and learning.

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- Difficult to assign time slots.
- Overall plan should have sufficient looseness which would be padded out by thoughts.
- Writing, programming, experimenting.
- Teaching and giving presentations.
- Reviewing.
- Others: installing computers and software, emails, administration (filling-up forms), ...

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## You and your research

- Read the paper **You and your research** by **Richard W Hamming**, **Bell Communications Research Colloquium Seminar**, 7th March 1986

*What Thinking Skills are required  
in research ?*

- Creativity

- Creativity
- Problem solving

- Creativity
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- Problem finding

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- Creativity
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## Reproductive and Productive thinking

- Our thinking is generally reproductive i.e. based on the similar problems encountered in the past or the problems one is taught to solve.

- Creativity
- Problem solving
- Problem finding

## Reproductive and Productive thinking

- Our thinking is generally reproductive i.e. based on the similar problems encountered in the past or the problems one is taught to solve.
- However, we must learn to do productive thinking i.e. generate as many alternate approaches as possible

Levels of thinking - ordered low to high

- 1 Knowing

What is creativity

Levels of thinking - ordered low to high

- 1 Knowing
- 2 Comprehension

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## What is creativity

- An example to illustrate what is critical thinking or creativity?



Levels of thinking - ordered low to high

- ① Knowing
- ② Comprehension
- ③ Application or Problem solving
- ④ Evaluation or Critical Thinking
- ⑤ Creativity

## What is creativity

- An example to illustrate what is critical thinking or creativity?
- **Ability to apply knowledge equips one with creative thinking.** What is the latent inference of this statement?

# *Critical Thinking vs Intelligence*

- The question asked as an example was **How to cut a square piece of paper into five equal squares?**

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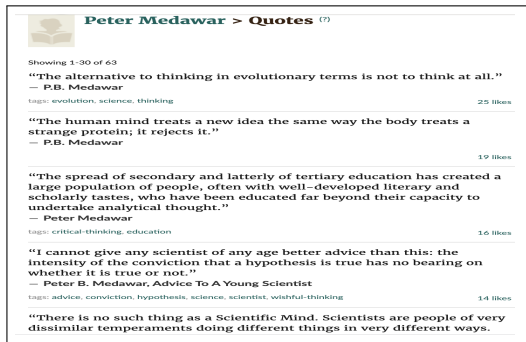
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- The question asked as an example was **How to cut a square piece of paper into five equal squares?**
- How to solve this problem ?
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- Two strikingly different ways of framing this question?
- This proves clear distinction between the Creative Thinking **required in research** and mere applying knowledge to solve a problem.

Is creative thinking a gift or a skill ?

Peter Medawar's observations

- *That creativity is beyond analysis is a romantic illusion we must now outgrow*



The screenshot shows a web page titled "Peter Medawar > Quotes (?)". It features a small icon of an open book with a flower growing from it. Below the title, it says "Showing 1-30 of 63". There are four quotes listed, each with a "likes" count. The quotes are:


- "The alternative to thinking in evolutionary terms is not to think at all." — P.B. Medawar (25 likes). Tags: evolution, science, thinking.
- "The human mind treats a new idea the same way the body treats a strange protein; it rejects it." — P.B. Medawar (19 likes).
- "The spread of secondary and latterly of tertiary education has created a large population of people, often with well-developed literary and scholarly tastes, who have been educated far beyond their capacity to undertake analytical thought." — Peter Medawar (16 likes). Tags: critical-thinking, education.
- "I cannot give any scientist of any age better advice than this: the intensity of the conviction that a hypothesis is true has no bearing on whether it is true or not." — Peter B. Medawar, Advice To A Young Scientist (14 likes). Tags: advice, conviction, hypothesis, science, scientist, wishful-thinking.
- "There is no such thing as a Scientific Mind. Scientists are people of very dissimilar temperaments doing different things in very different ways."

Figure: Medawar's Quotes about Creativity



What is the difference between the intelligence and the creativity?

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The screenshot shows the Wikipedia article for Marilyn vos Savant. At the top, there are tabs for 'Article' and 'Talk', and buttons for 'Read', 'Edit', and 'View history'. A search bar is also present. The main heading is 'Marilyn vos Savant'. Below it, a sub-header says 'From Wikipedia, the free encyclopedia'. The main text describes her as an American magazine columnist with the highest recorded IQ, mentioning her work on the 'Ask Marilyn' column in Parade magazine and her appearance on the Monty Hall problem. To the right, there is a summary box with her birth details (Marilyn Mach, August 11, 1946, St. Louis, Missouri, U.S.), her occupation (Author - columnist), and her spouse (Robert Jarvik, m. 1987). At the bottom left of the article content, there is a 'Contents' link with a 'hide' button.

Article [Talk](#) [Read](#) [Edit](#) [View history](#)

## Marilyn vos Savant

From Wikipedia, the free encyclopedia

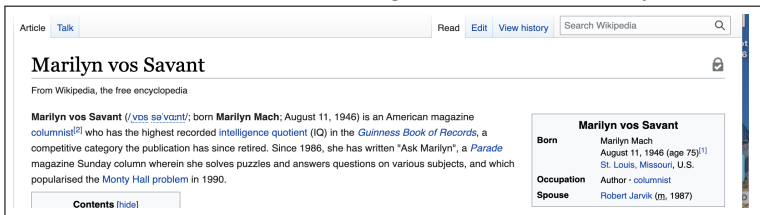
**Marilyn vos Savant** (/ˈvɒs səˈvɑːnt/; born **Marilyn Mach**; August 11, 1946) is an American magazine columnist<sup>[2]</sup> who has the highest recorded *intelligence quotient* (IQ) in the *Guinness Book of Records*, a competitive category the publication has since retired. Since 1986, she has written "Ask Marilyn", a *Parade* magazine Sunday column wherein she solves puzzles and answers questions on various subjects, and which popularised the *Monty Hall problem* in 1990.

[Contents](#) [hide](#)

<b>Marilyn vos Savant</b>	
<b>Born</b>	<div>Marilyn Mach</div> <div>August 11, 1946 (age 75)<sup>[1]</sup></div> <div>St. Louis, Missouri, U.S.</div>
<b>Occupation</b>	Author · <a href="#">columnist</a>
<b>Spouse</b>	<a href="#">Robert Jarvik</a> (m. 1987)

Figure: Highest IQ:But mere columnist

What is the difference between the intelligence and the creativity?

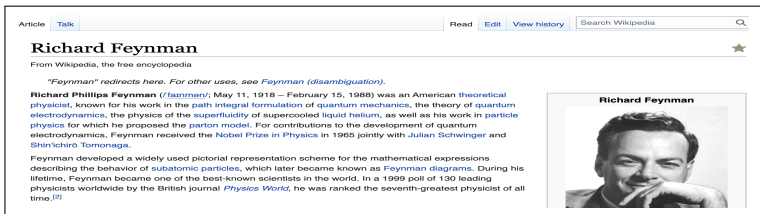


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Marilyn vos Savant	
<b>Born</b>	Marilyn Mach August 11, 1946 (age 75) <sup>[1]</sup> St. Louis, Missouri, U.S.
<b>Occupation</b>	Author · columnist
<b>Spouse</b>	Robert Jarvik (m. 1987)

At the bottom left of the article content, there is a "Contents" link with a "(hide)" option.

Figure: Highest IQ: But mere columnist



The screenshot shows the Wikipedia article for Richard Feynman. The article title is "Richard Feynman" with a star icon indicating it is a featured article. Below the title, it says "From Wikipedia, the free encyclopedia". The main text describes him as an American theoretical physicist, known for his work in the path integral formulation of quantum mechanics, the theory of quantum electrodynamics, the physics of the superfluidity of supercooled liquid helium, as well as his work in particle physics for which he proposed the parton model. It mentions his Nobel Prize in Physics in 1965 jointly with Julian Schwinger and Shin'ichirō Tomonaga. On the right, there is a portrait of Richard Feynman. The article also mentions his development of a widely used pictorial representation scheme for the mathematical expressions describing the behavior of subatomic particles, which later became known as Feynman diagrams.

Figure: IQ 122: But Nobel prize and known as the last American genius

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## Intelligent but passive

Thus one can be intelligent but **be rigid, non-creative** or lacking in the kind of **single-minded passion** that drives the **creators**



- The definition of Critical Thinking....

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<sup>1</sup> <https://collegeinfo geek.com/team/ransom-patterson/>

- The definition of Critical Thinking....
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- It is just deliberately and systematically processing information so that one can make better decisions and generally understand things better.
- Critical thinking is the opposite of regular, everyday thinking. <sup>1</sup>

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- **Creativity** is the ability to look at the same aspect a everyone else and **think something different** with an aim to improve the **state-of-the-art** in that domain.



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Optimistic	Roses
Pessimistic	Thorns
Realistic	Roses and thorns
Stoic	Roses and thorns
Humane	Roses for you and roses for me
Selfish	Roses for me and thorns for you
Sadistic	Thorns for you and your blood for me
Divine	Roses for you and your thorns for me

# Developing Creativity

Creativity can be developed by

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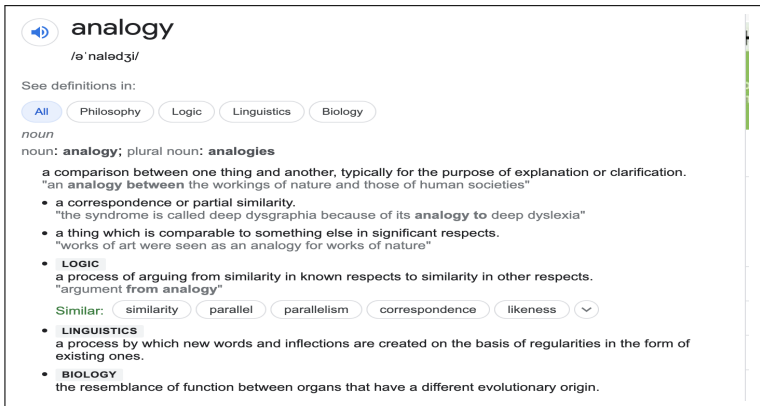
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**analogy**  
/əˈnælədʒi/

See definitions in:

**All** Philosophy Logic Linguistics Biology

*noun*  
noun: **analogy**; plural noun: **analogies**

a comparison between one thing and another, typically for the purpose of explanation or clarification.  
"an **analogy** between the workings of nature and those of human societies"

- a correspondence or partial similarity.  
"the syndrome is called deep dysgraphia because of its **analogy** to deep dyslexia"
- a thing which is comparable to something else in significant respects.  
"works of art were seen as an analogy for works of nature"
- **LOGIC**  
a process of arguing from similarity in known respects to similarity in other respects.  
"argument **from analogy**"

**Similar:** similarity parallel parallelism correspondence likeness

- **LINGUISTICS**  
a process by which new words and inflections are created on the basis of regularities in the form of existing ones.
- **BIOLOGY**  
the resemblance of function between organs that have a different evolutionary origin.

Figure: Analogy definitions



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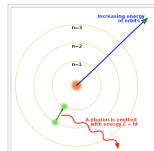
## Analogy

From Wikipedia, the free encyclopedia

For other uses, see *Analogy (disambiguation)*.

**Analogy** (from Greek *analogia*, "proportion", from *ana-* "upon, according to" [also "against", "anew"] + *logos* "ratio" [also "word, speech, reckoning"]<sup>[1][2]</sup>) is a **cognitive** process of transferring **information** or **meaning** from a particular subject (the analog, or source) to another (the target), or a **linguistic** expression corresponding to such a process. In a narrower sense, analogy is an **inference** or an **argument** from one particular to another particular, as opposed to **deduction**, **induction**, and **abduction**, in which at least one of the **premises**, or the conclusion, is general rather than particular in nature. The term analogy can also refer to the relation between the source and the target themselves, which is often (though not always) a **similarity**, as in the **biological notion of analogy**.

Analogy plays a significant role in **problem solving**, as well as **decision making**, **argumentation**, **perception**, **generalization**, **memory**, **creativity**, **invention**, **prediction**, **emotion**, **explanation**, **conceptualization** and **communication**. It lies behind basic tasks such as the identification of places, objects and people, for example, in **face perception** and **facial recognition systems**. It has been argued that analogy is "the core of cognition".<sup>[3]</sup> Specific analogical language comprises **exemplification**, **comparisons**, **metaphors**, **similes**, **allegories**, and **parables**, but *not* **metonymy**. Phrases like *and so on*, *and the like*, *as if*, and the very word *like* also rely on an analogical understanding by the receiver of a **message** including them. Analogy is important not only in **ordinary language** and **common sense** (where **proverbs** and **idioms** give many examples of its application) but also in **science**, **philosophy**, **law** and the **humanities**. The concepts of **association**, **comparison**, **correspondence**, **mathematical** and **morphological homology**, **homomorphism**, **iconicity**, **isomorphism**, **metaphor**, **resemblance**, and **similarity** are closely related to analogy. In **cognitive linguistics**, the notion of **conceptual metaphor** may be equivalent to that of analogy. Analogy is also a basis for any comparative arguments as well as experiments whose results are transmitted to objects that have been not under examination (e.g., experiments on rats when results are applied to humans).



Rutherford's model of the atom (modified by Niels Bohr) made an analogy between the atom and the solar system.

Figure: Analogy explanation on Wiki

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## Critical Thinking, again

Do we now understand on what the foundations of research rest ? Are we really prepared to undertake research ?

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Read the blog at <https://www.teachthought.com/critical-thinking/examples-of-analogies/>

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- Different ways of calculating  $\pi$



# *Critical Thinking and 7 Ways to Improve Critical Thinking Skills*

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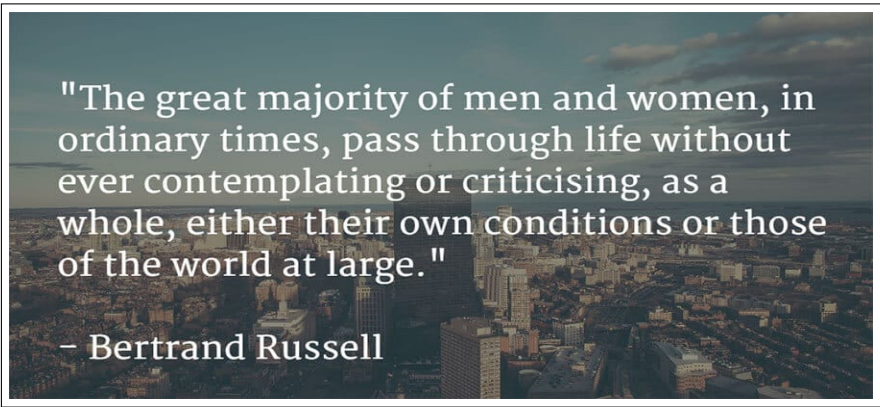
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# Why is Critical Thinking essential ?...

An aerial photograph of a city skyline, likely New York City, taken from a high vantage point. The image shows a dense cluster of skyscrapers and buildings, with the sun setting or rising, creating a warm, golden light over the city. The sky is a mix of blue and orange hues. The quote is overlaid in white text on the left side of the image.

"The great majority of men and women, in ordinary times, pass through life without ever contemplating or criticising, as a whole, either their own conditions or those of the world at large."

– Bertrand Russell

Figure: The value of critical thinking

# Why is Critical Thinking essential ?...: Finally, the laundry list

Finally the laundry list that summarizes all the points discussed previously:

- allows one to continue to develop intellectually:

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- **makes one more employable (and better paid):**
  - the best employees not only know how to solve existing problems—they also know how to come up with solutions to problems no one ever imagined.

# Why is Critical Thinking essential ?...

"Thinking is skilled work. It is not true that we are naturally endowed with the ability to think clearly and logically – without learning how, or without practicing."

– A.E. Mander

Figure: The value of critical thinking

# 7 Ways to Improve Critical Thinking Skills: Laundry List

7 ways to improve critical thinking skills

- Ask Basic Questions

# 7 Ways to Improve Critical Thinking Skills: Laundry List

7 ways to improve critical thinking skills

- Ask Basic Questions
- Question Basic Assumptions



# 7 Ways to Improve Critical Thinking Skills: Laundry List

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- Ask Basic Questions
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- Question Basic Assumptions
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- Question Basic Assumptions
- Be Aware of One's Own Mental Processes
- Try Reversing Things
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# 7 Ways to Improve Critical Thinking Skills: Laundry List

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- Question Basic Assumptions
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- Understand That No One Thinks Critically 100% of the Time

## 7 Ways to Improve ... Focus on Basic questions

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  - Sometimes an explanation becomes so complex that the original question get lost.
  - To avoid this, continually one must go back to the basic questions when one set out to solve the problem.

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## 7 Ways to Improve ...: Question Basic Assumptions

- **Question Basic Assumptions:** it's quite easy to make an ass of oneself simply by failing to question the basic assumptions.

**"When you assume, you make an ass out of you and me."** – An old proverb

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  - A good example is to check out **Oblique Strategies**<sup>3</sup>

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  - This was beneficial to humans when we were hunting large game and fighting off wild animals, but it can be disastrous when we're trying to decide who to vote for.
  - A critical thinker is aware of their cognitive biases and personal prejudices and how they influence seemingly "objective" decisions and solutions.

# 7 Ways to Improve ... : Try Reversing the Things

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- Remember to Think for One's Ownself :
  - One should not be overconfident, but yet recognize that thinking for one's ownself is essential to answering tough questions.

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# 7 Ways to Improve ...: Critical Thinking is not perennial

- Critical thinking is not omnipresent nor continuous :

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- Techniques of Representation of Knowledge

# *Issues in the Access and the Representation of Knowledge*

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- An example in the next slide makes this aspect very clear

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# Knowledge representation: Dangers of Inert knowledge

- As an illustration, consider the following question that was posed to college juniors students *Try to remember what you learned about the concept of logarithms. Can you think of any way that they might make problem solving simpler than it would be if they did not exist?"*<sup>5</sup>

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  - most students have difficulty answering these questions unless provided with hints or clues.

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  - Case II: When given a clue and then presented with the problems, but **not explicitly prompted to use the clue information**, their problem-solving performance was poor i.e.

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# Knowledge representation: Dangers of Inert knowledge ...

- In another experimentation, the students were provided **with cues that were very closely related** to problems to be solved later <sup>7</sup>
- The problems to be solved were "insight" problems such as the following
  - *Uriah Fuller, the famous Israeli superpsychic, can tell you the score of any baseball game before the game starts. What is his secret?*
- The students first received statements/clues such as *Before it starts, the score of any game is 0 to 0.*
- Two different results as follows, were observed
  - Case I: When given a clue and then presented with the problems and **explicitly prompted to use the clue information** (which was now stored in memory), their problem-solving performance was excellent.
  - Case II: When given a clue and then presented with the problems, but **not explicitly prompted to use the clue information**, their problem-solving performance was poor i.e.
    - the uninformed students could not spontaneously access the correct answers to exploit the obvious relationship between the problems and the clues.

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  - In this experiment following the acquisition of information, all students were asked to recall what they had learned about attention.
  - Then, data were collected two days after the initial experiment, wherein the students were asked to estimate how often they had thought about the concept of attention once they had left the experiment and to state the conditions under which these thoughts occurred.

.....continued

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# Knowledge representation: Facilitating knowledge access ...

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- Under these conditions, access to relevant information seems to be much more likely to occur.

# *Techniques for Representation of Knowledge*

The Problem Finding strategies consist of the following

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# *Differences in Approaches to Learning and Problem Solving*

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- To be written from the paper at <sup>8</sup>

---

<sup>8</sup>Bransford et al: Teaching Thinking and Problem Solving



# *Formulation of a problem*

# *How to initiate research ?*

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It is clear **active learning** is very vital in research

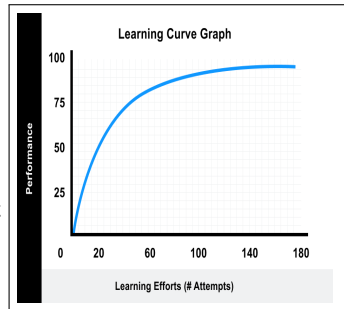


Figure: Learning Curve

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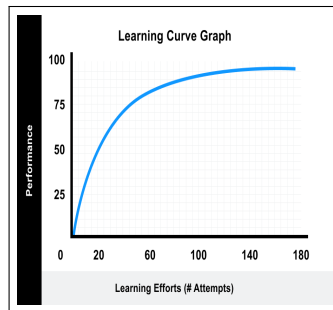


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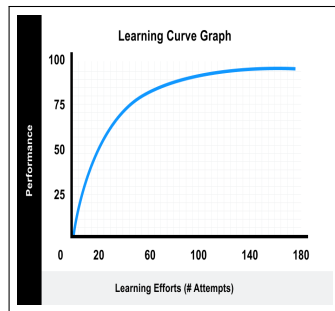


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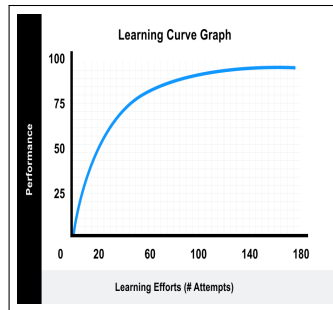


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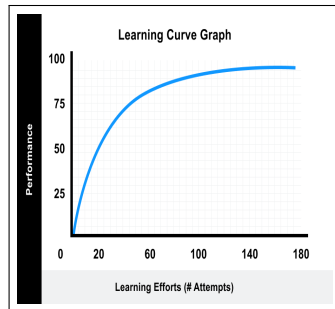


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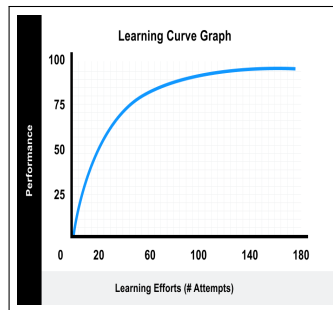


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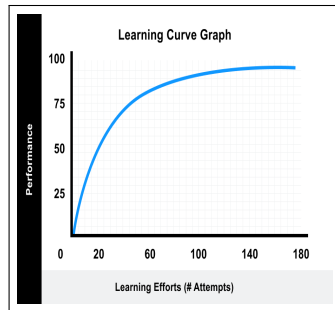


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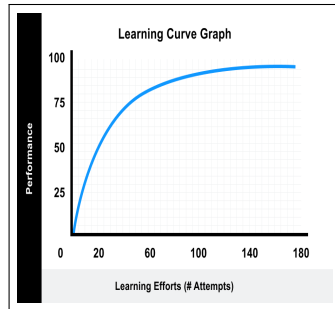


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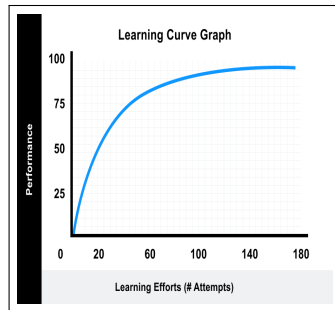


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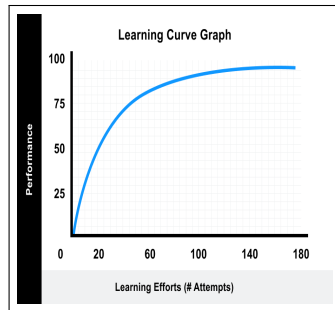


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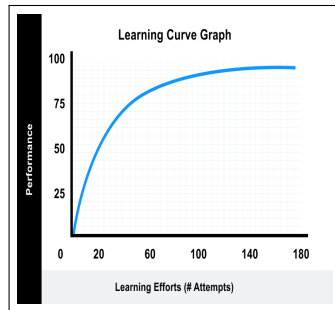


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Figure: Learning Curve

Improving the learning curve

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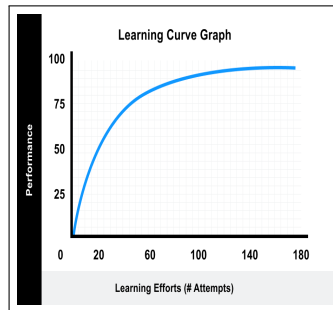


Figure: Research Process

## Improving the learning curve

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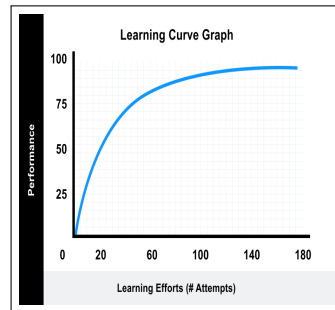


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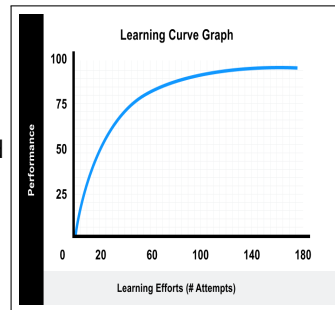


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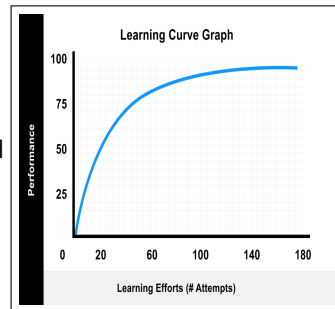


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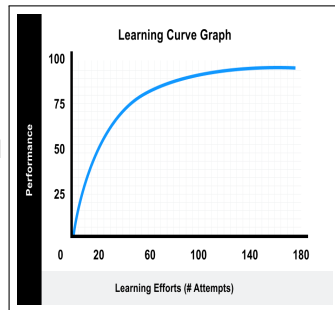


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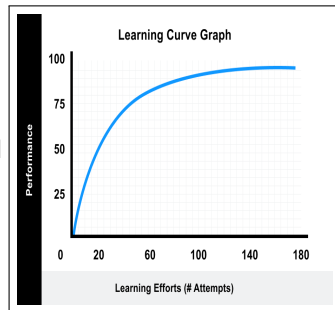


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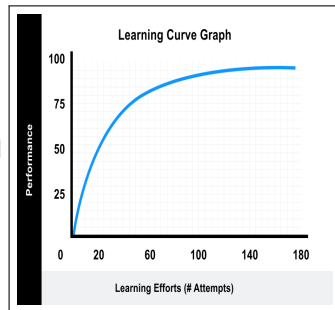


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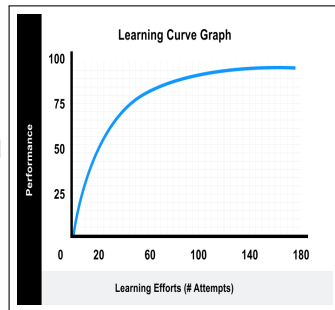


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  - Sometimes the journey can be bottom-up.
  - This can happen : when you are led to a problem through a connection to another problem whose top-structure is different.

*How to find a new research problem ?*

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- Getting to the core of the paper.
  - Stated **open problems** should be seen in a broader context.

# Looking for Problems...

*“Don’t just read it; fight it! Ask your own questions, look for your own examples, discover your own proofs. Is the hypothesis necessary? Is the converse true? What happens in the classical special case? What about the degenerate cases? Where does the proof use the hypothesis?”*

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  - Requires being abreast of related subjects/areas/topics.

# Asking Questions...

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- What do students think about my teaching?



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# *Attributes of a good research problem*

# *Constructing hypotheses*

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