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Introduction

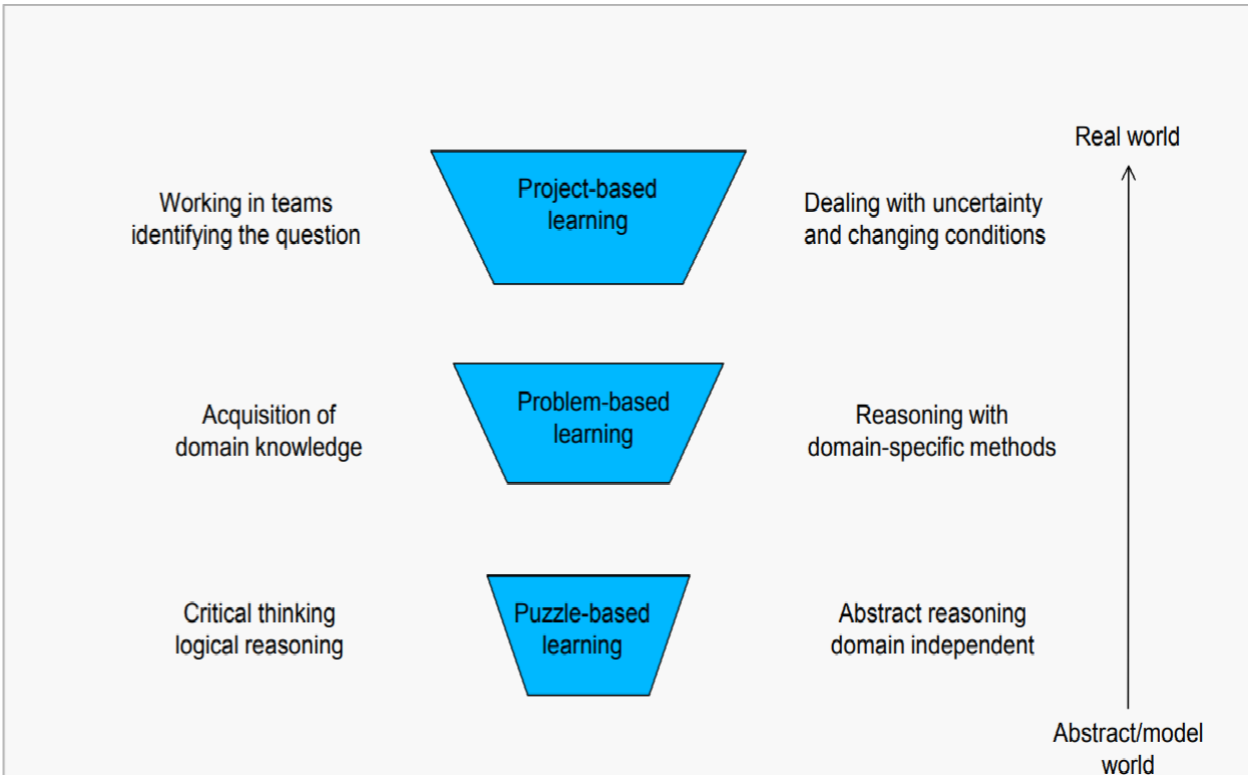
In this class we'll Learn about ourselves, Problem Solving and Critical Thinking techniques that solve a wide variety of problems. A lot of the problems/solutions discussed here will be computer related but can be applied to any domain/field of study.

Why is this important ? because you can apply these techniques to every aspect of your life!

Guiding Philosophy

1. Problem solving is a skill (it can be learned). It is not an innate ability.
2. Problem solving is fundamentally about attitude and effort (the "problem-solving stance"). Your attitude should be constructive and always focused on the problem. You should also be focused on your effort and determination and make sure you're making progress toward a workable solution. Remember the only time you lose is when you give up !!!
3. The problem-solving stance isn't something that you can just "turn on" when you need it for a test, etc. You have to live it – and successful people do just that (i.e. be a Critical Thinker !)

A Learning Hierarchy



Learn about yourself

Know thyself.

Ancient Greek Aphorism

The unexamined life is not worth living.

Socrates

A man must be big enough to admit his mistakes, smart enough to profit from them, and strong enough to correct them.

J C Maxwell

This is not "what you are". It is "right now, what you prefer" (and strength of preference). Results can vary from test to test or day to day by several points. For example, most introverts can operate in extrovert mode when needed. Your presenter has always been an Introvert but has learned extroverted skills like presenting this material.

Online Personality Test

Please take this 15 minute personality test here to learn more about yourself. Make sure to save your type so you can learn more about yourself. Remember you should play to yours strengths and learn and work on your weaknesses. Here's mine http://www.humanmetrics.com/personality/intj-type?EI=-28&SN=-9&TF=28&JP=16

Characteristics of a successful Problem Solver

See also http://www.co-bw.com/BSC_CPS_characteristics_of_PS.htm

Problem Solving

Problem solving is applying problem solving strategies to find solutions to problems

Strategies

- Abstraction
  solving the problem in a model of the system before applying it to the real system
  e.g. this is used extensively in software engineering. see here for example
  1 simple approach to designing OO systems is to use Noun/Verb classification using SOLID OO design principles
- Analogy
  using a solution that solves a similar problem
  e.g.
  Software Engineering Design Patterns with examples
  Used often in precedent case law.
- Brainstorming:
  (especially among groups of people) suggesting a large number of solutions or ideas and combining and developing them until an optimum solution is found. Very important to not restrict/judge/remove any idea until all ideas have been exhausted by the group.
  e.g. Marketing/Advertising use these technique to help solve complex difficult problems like "How can we make our customer love our product", "How can we beat our competition"
- Divide and Conquer

  breaking down a large, complex problem into smaller, solvable problems

  This is a very common technique. So common it is a synonym for analysis which comes from the Ancient Greek ἀνάλυσις (*analysis*, "a breaking up", from *ana-* "up, throughout" and *lysis* "a loosening"). Anywhere you see a hierarchical structure this technique was used

  In software engineering this technique is used everywhere from the of design programming languages, Data Structures, OO design, Design Patterns, Protocols (IP, DNS) ...

- Hypothesis testing:

  assuming a possible explanation to the problem and trying to prove (or, in some contexts, disprove) the assumption

  e.g. Prototyping ideas/concepts. Manual and automated Unit and Integration testing

- Lateral Thinking
  approaching solutions indirectly and creatively

  e.g. if a production line produced 1000 books per hour, lateral thinking may suggest that a drop in output to 800 would lead to higher quality, more motivated workers etc.

  Software quality and metrics, Mythical Man-Month " adding manpower to a late software project makes it later". Brainstorming and creativity helps in lateral thinking.

- Means-ends analysis: choosing an action at each step to move closer to the goal
  e.g. *goal-based* problem solving is 1 approach used in AI in which the solution of a problem can be described by finding a sequence of *actions* that lead to a desirable goal.

  Declarative programming languages like Prolog use this approach. The programmer creates the relationships represented as facts and rules. You perform a query of the program and a result is displayed. Here's a couple of simple prolog examples

- Proof: try to prove that the problem cannot be solved. The point where the proof fails will be the starting point for solving it

  e.g. Proof of concept is a realization of a certain method or idea in order to demonstrate its feasibility. Its demonstrates its main use case or original idea(s) and usually is small and may or may not be complete.

  Math uses proofs extensively. Can you name some proofs you learned in the classes you have taken ?

- Root cause analysis used for identifying the initial cause of faults or problems. because of the complexity of modern day computing systems the displayed error is rarely the root cause of the issue.

  e.g. users couldn't logon to www.mysubaru.com.

  a. Using mysubaru was very slow, so slow some users would timeout trying to login
  b. There were no errors in the error log
  c. This started happening when we released a new version of code to production the night before so I knew it was possible it was related to a code change we made
  d. Started up mysubaru on my pc pointing to production and tried to login with the credentials of the user who was having problems
  e. After looking at my log file, I noticed a few items took a long time and it was related to looking up vehicle information
  f. Found the statement that was looking up vehicle info, I was changed with this release and was performing much slower.
  g. Ran the problem and original query in the database, and confirmed it was taking much longer than the previous query that was replaced.
  h. Asked the DBA to make the current query faster by adding indexes on the query and that fixed the issue
  i. This problem didn't reveal its self in dev and qa environments because the amount of data and number of users is much lower in these environments so it went unnoticed.

- Trial-and-error: testing possible solutions until the right one is found

  e.g. See Root Cause analysis example

  e.g. Biological evolution can be considered as a form of trial and error.[6] Random mutations and sexual genetic variations can be viewed as trials and poor reproductive fitness, or lack of improved fitness, as the error. Thus after a long time 'knowledge' of well-adapted genomes accumulates simply by virtue of them being *able* to reproduce.

Other Techniques

- Method of focal objects: synthesizing seemingly non-matching characteristics of different objects into something new
- Morphological analysis: assessing the output and interactions of an entire system
- Reduction: transforming the problem into another problem for which solutions exist
- Research: employing existing ideas or adapting existing solutions to similar problems

Commong Barriers to Problem Solving

Confirmation Bias

also called confirmatory **bias** or myside **bias**, is the tendency to search for, interpret, favor, and recall information in a way that confirms one's preexisting beliefs or hypotheses. ... The effect is stronger for emotionally charged issues and for deeply entrenched beliefs.

e.g. During an election season, for example, people tend to seek positive information that paints their favored candidates in a good light. They will also look for information that casts the opposing candidate in a negative light. By not seeking out objective facts, interpreting information in a way that only supports their existing beliefs, and only remembering details that uphold these beliefs, they often miss important information.

e.g Consider the debate over gun control. Sally, for example, is in support of gun control. She seeks out news stories and opinion pieces that reaffirm the need for limitations on gun ownership. When she hears stories about shootings in the media, she interprets them in a way that supports her existing beliefs. Henry, on the other hand, is adamantly opposed to gun control. He seeks out news sources that are aligned with his position. When he comes across news stories about shootings, he interprets them in a way that supports his current point of view.These two people have very different opinions on the same subject and their interpretations are based on that. Even if they read the same story, their bias tends to shape the way they perceive it because it confirms their beliefs.

Mental Set

mental set describes one's inclination to attempt to solve problems in such a way that has proved successful in previous experiences, Even when simpler solutions have been demonstrated to them. Therefore, it is often necessary for people to move beyond their mental sets in order to learn and grow

e.g. There are six eggs in a basket, Six people take one of each, How is it that one egg can still be left in the basket? A. the sixth person took the basket as well as the last egg still inside

e.g. You typically enter a store by pushing a door open. Every time they come to a door after that, you push the door expecting it to open, even though some doors only open by pulling.

Functional Fixedness

Functional fixedness is a specific form of mental set and fixation, the "[s]ubjects become "fixed" on the design function of the objects, and problem solving suffers relative to control conditions in which the object's function is not demonstrated.

e.g. For instance, imagine the following situation: a man sees a bug on the floor that he wants to kill, but the only thing in his hand at the moment is a can of air freshener. If the man starts looking around for something in the house to kill the bug with instead of realizing that the can of air freshener could in fact be used not only as having its main function as to freshen the air, he is said to be experiencing functional fixedness

Unnecessary constraints

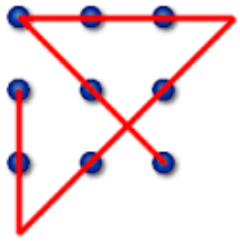
This particular phenomenon occurs when the subject, trying to solve the problem subconsciously, places boundaries on the task at hand, which in turn forces him or her to strain to be more innovative in their thinking

e.g.

but the most well-known example of this barrier making itself present is in the famous example of the dot problem. In this example, there are nine dots lying in a square- three dots across, and three dots running up and down. The solver is then asked to draw no more than four lines, without lifting their pen or pencil from the paper. This series of lines should connect all of the dots on the paper. Then, what typically happens is the subject creates an assumption in their mind that they must connect the dots without letting his or her pen or pencil go outside of the square of dots.

To see the solution goto to next page

Get a pen and some paper and copy the **nine dots** arranged in a square below. To solve the problem, you need to join all **nine dots** by drawing no more than **four** straight **lines**. The straight **lines** must be continuous – i.e. you must not lift your pen from the paper once you start drawing. Dec 8, 2008



Why Thinking “Outside the Box” Doesn't Work - Lateral Action
https://lateralaction.com/articles/thinking-outside-the-box/

Irrelevant information

Irrelevant information is information presented within a problem that is unrelated or unimportant to the specific problem.[33] Within the specific context of the problem, irrelevant information would serve no purpose in helping solve that particular problem.

e.g. "Fifteen percent of the people in Topeka have unlisted telephone numbers. You select 200 names at random from the Topeka phone book. How many of these people have unlisted phone numbers?"

The people that are not listed in the phone book would not be among the 200 names you selected. The individuals looking at this task would have naturally wanted to use the 15% given to them in the problem. They see that there is information present and they immediately think that it needs to be used. This of course is not true. These kinds of questions are often used to test students taking aptitude tests or cognitive evaluations.[41] They aren't meant to be difficult but they are meant to require thinking that is not necessarily common. *Irrelevant Information* is commonly represented in

math problems, word problems specifically, where numerical information is put for the purpose of challenging the individual.

Collective problem solving

It has been noted that the complexity of contemporary problems has exceeded the cognitive capacity of any individual and requires different but complementary expertise and collective problem solving ability.[43]

Collective intelligence is shared or group intelligence that emerges from the collaboration, collective efforts, and competition of many individuals.

Here are some of the skills needed for Collective Problem solving.

Critical Thinking

Critical thinking is the objective analysis of facts to form a judgment.

Logic

The ability to reason logically is a fundamental skill, the 2 standard forms of logic reasoning are and deductive and inductive reasoning

Deductive

This type of reasoning is "top down". Deductive Reasoning involves addressing the known first, and attempt to discover more information about why the known is what it is. root cause analysis and top down learning use deductive reasoning.

e.g. All squares are rectangles. All rectangles have four sides. Logic, therefore, tells you that all squares have four sides.
e.g. It is dangerous to drive when it is snowing. It is snowing now. Logic tells you that it would be dangerous to drive right now.

Inductive

This type of reasoning is "bottom up". Inductive thinking involves drawing on many different facts, concepts, or opinions to come to a larger conclusion. Inductive reasoning include differential diagnosis, inquiry-based education, and trial and error.

e.g. Every house that burned down on the block was caused by faulty wiring. You conclusion is that all homes on the block have faulty wiring.

e.g. Every three year old you see at the park every afternoon spends most of their time crying and screaming. Your conclusion is that all three year olds spend their afternoon screaming.

Functions

The list of core critical thinking skills includes observation, interpretation, analysis, inference, evaluation, explanation, and metacognition. According to Reynolds (2011), an individual or group engaged in a strong way of critical thinking gives due consideration to establish for instance:[14]

- Evidence through reality
- Context skills to isolate the problem from context[*clarification needed*]
- Relevant criteria for making the judgment well
- Applicable methods or techniques for forming the judgment
- Applicable theoretical constructs for understanding the problem and the question at hand

In addition to possessing strong critical-thinking skills, one must be disposed to engage problems and decisions using those skills. Critical thinking employs not only logic but broad intellectual criteria such as clarity, credibility, accuracy, precision, relevance, depth, breadth, significance, and fairness

Procedure

Critical thinking calls for the ability to:

- Recognize problems, to find workable means for meeting those problems
- Understand the importance of prioritization and order of precedence in problem solving
- Gather and marshal pertinent (relevant) information
- Recognize unstated assumptions and values
- Comprehend and use language with accuracy, clarity, and discernment
- Interpret data, to appraise evidence and evaluate arguments
- Recognize the existence (or non-existence) of logical relationships between propositions
- Draw warranted conclusions and generalizations
- Put to test the conclusions and generalizations at which one arrives
- Reconstruct one's patterns of beliefs on the basis of wider experience
- Render accurate judgments about specific things and qualities in everyday life

In sum:

"A persistent effort to examine any belief or supposed form of knowledge in the light of the evidence that supports or refutes it and the further conclusions to which it tends."

Additional Information

Free Courses

https://www.udemy.com/introduction-to-problem-solving/

https://www.coursera.org/learn/problem-solving

https://www.careerbuilder.com/advice/what-are-problemsolving-skills-and-why-are-they-important

https://www.coursera.org/learn/mindware

Related to Computer Science

http://courses.cs.vt.edu/cs2104/Fall17Barnette/

http://courses.cs.vt.edu/cs2104/

https://www.slideshare.net/MIWorksMO/critical-thinking-and-problem-solving-41823850

https://www.quora.com/What-is-the-relationship-between-problem-solving-and-critical-thinking

Summary

- Problem solving is a skill (it can be learned). It is not an innate ability.
- Problem solving is fundamentally about attitude and effort
- To be a successful Problem Solver/Critical Thinker you need to live it
- Know yourself ! Remember you should play to yours strengths and learn and work on your weaknesses

Strategies

- Abstraction: solving the problem in a model of the system before applying it to the real system
- Analogy : using a solution that solves a similar problem
- Brainstorming: (especially among groups of people) suggesting a large number of solutions or ideas and combining and developing them until an optimum solution is found. Very important to not restrict/judge/remove any idea until all ideas have been exhausted by the group.
- Divide and Conquer: breaking down a large, complex problem into smaller, solvable problems
- Hypothesis testing: assuming a possible explanation to the problem and trying to prove (or, in some contexts, disprove) the assumption
- Lateral Thinking: approaching solutions indirectly and creatively
- Means-ends analysis: choosing an action at each step to move closer to the goal
- Proof: try to prove that the problem cannot be solved. The point where the proof fails will be the starting point for solving it
- Root cause analysis used for identifying the initial cause of faults or problems.

Common Problems encountered

- Confirmation Bias: Have others independently challenge/test your strategies/solution.
- Mental Set: Learn to Challenge/test and accept different approaches/ strategies other than ones you know work.
- Functional Fixedness: Learn to be creative in how you use your tools and judge your result on the simple test “Is it effective and/or useful”
- Unnecessary constraints Be creative in your solutions and be aware of the constraints that are being imposed ? are they defined by the problem or by you? Improving your Mental Set and Functional Fixedness will help
- Irrelevant information :Stay focused on the relevant information that helps you move you closer to the solution. if the problem is complex and has many variables try and compare it to a similar problem that has a solution and use it as a guide

Collective problem solving

- We all need to work collectively and cooperatively towards the goal. No 1 person has all the answers and our power lies in our collective intelligence and social relationships

Critical Thinking

- Logic and Rationality: The ability to reason logically is a fundamental skill of rational agents, hence the study of the form of correct argumentation is relevant to the study of critical thinking
- Inductive versus deductive thinking Inductive thinking involves drawing on many different facts, concepts, or opinions to come to a larger conclusion. Examples of inductive reasoning include differential diagnosis, inquiry-based education, and trial and error. Deductive Reasoning involves addressing the known first, and attempt to discover more information about why the known is what it is. Examples of deductive reasoning include root cause analysis and top down learning.
- Functions The list of core critical thinking skills includes observation, interpretation, analysis, inference, evaluation, explanation, and metacognition.
- Procedure "A persistent effort to examine any belief or supposed form of knowledge in the light of the evidence that supports or refutes it and the further conclusions to which it tends."