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Computational Thinking

"Skills to Catch the Future"

Erasmus+ KA220

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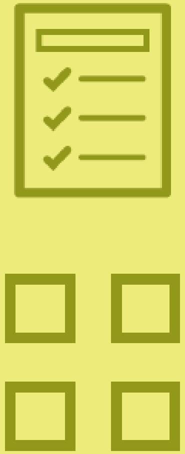
What is computational thinking?

Computational thinking is a way of solving problems, designing systems, and understanding human behavior that draws on concepts and techniques from computer science. It involves breaking down complex problems into smaller, more manageable parts, and using logical reasoning and data analysis to find solutions.

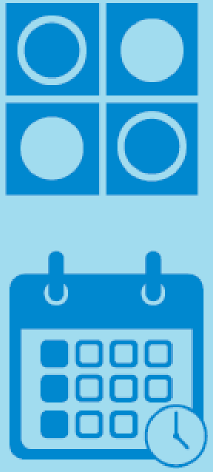
Computational thinking skills are useful in a wide range of fields, including computer science, data science, education, and business. They are also important for understanding and participating in the digital world.

Some key principles of computational thinking include:

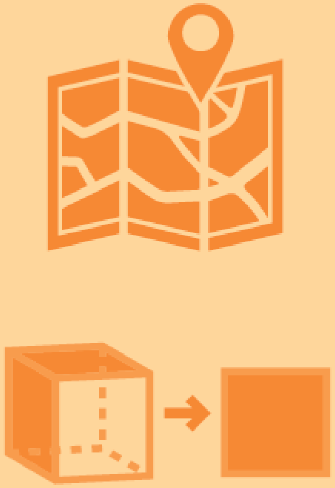
Decomposition



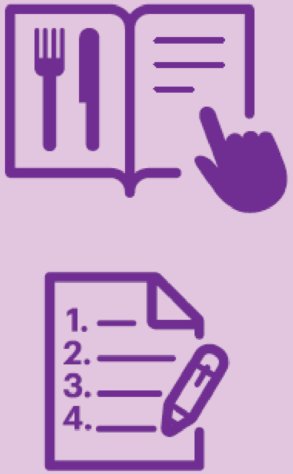
Pattern Recognition



Abstraction

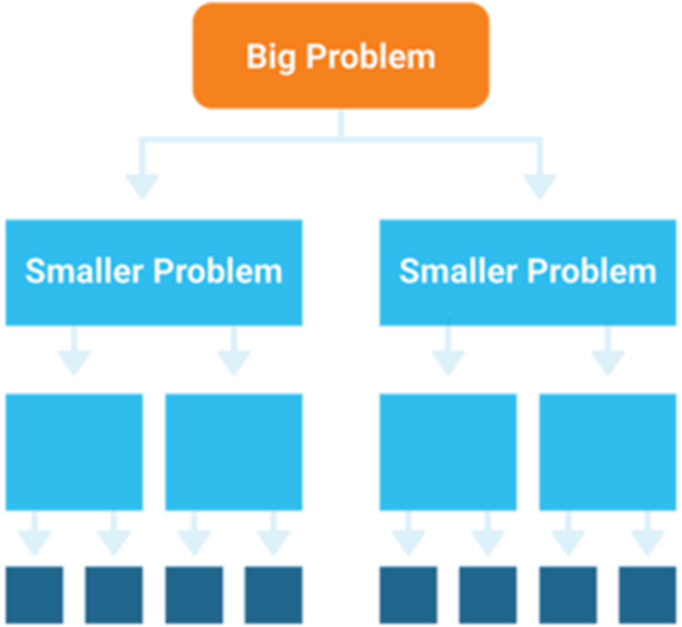


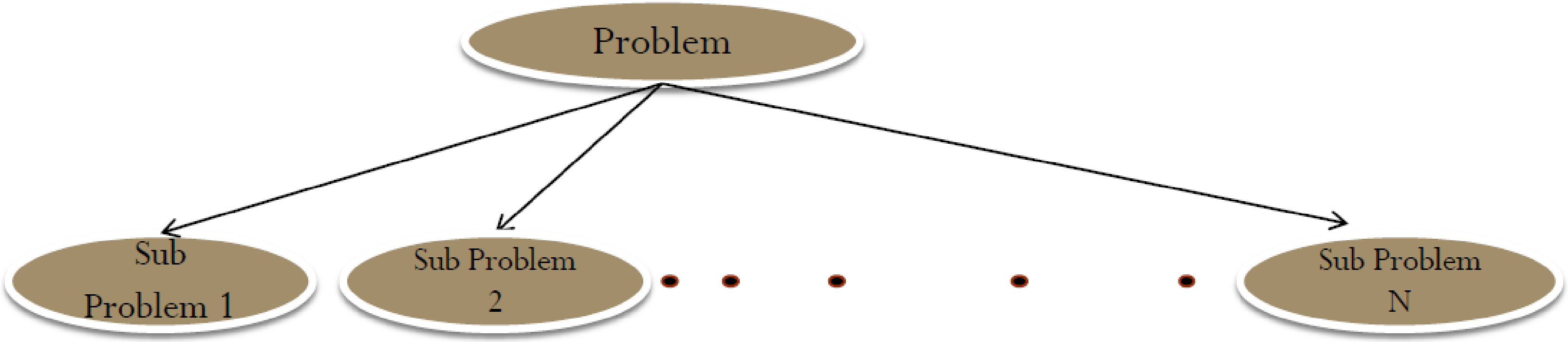
Algorithm



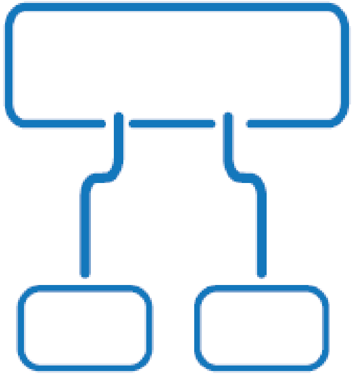
https://www.youtube.com/watch?v=6zqibjzKNdA

I. Decomposition





Decomposition



Breaking down complex problems or system into smaller parts that are more manageable and easier to understand.

The smaller parts can then be examined and solved, or designed individually, as they are simpler to work with.

The process of breaking down a complex problem into smaller, manageable parts is called **Analysis.** This involves identifying the major components of the problem, understanding their relationships, and finding solutions to the identified components.

Analysis should involve both qualitative and quantitative methods and involve looking at the problem from multiple perspectives.

In contrast, the process of combining the smaller components identified during the analysis stage into a unified solution is called **Synthesis**. This involves combining the different perspectives and solutions identified in the analysis stage to create an overall solution to the problem. Synthesis takes a holistic view of the problem and involves the integration of multiple solutions and perspectives. This process encourages creativity and innovation and can help to identify solutions that are more effective and efficient than those identified in the analysis stage.

Analysis

Examples of quantitative methods include:

1. Cost-benefit analysis: This method involves assessing the relative costs and benefits associated with different solutions to a problem.

2. Statistical analysis: This method uses data and statistics to analyze the problem and identify potential solutions.

3. Simulation: This method uses computer models to simulate scenarios and predict potential outcomes.

4. Optimization: This method uses mathematical algorithms to optimize a solution so that it is the most efficient and effective.

Examples of qualitative methods include:

1. Interviews: This method involves speaking to stakeholders and gathering information to gain a better understanding of the problem.
2. Surveys: This method uses questionnaires to identify potential solutions.
3. Brainstorming: This method involves gathering a group of people together to brainstorm ideas and potential solutions.
4. Observation: This method involves observing people and processes to gain a better understanding of the problem.

Synthesis

Examples of synthesis in problem decomposition include:

1. Combining multiple solutions: This involves combining different solutions identified during the analysis stage to create a unified solution.

2. Creating a new solution: This involves using the components identified in the analysis stage to create a new solution to the problem.

3. Adapting existing solutions: This involves adapting existing solutions to fit the problem better.

4. Refining existing solutions: This involves making small changes to existing solutions to make them more effective

Examples of Decomposition in Everyday Life 1/3

1. **English Language Arts:** Students analyze themes in a text by first answering: Who is the protagonist and antagonist? Where is the setting? What is the conflict? What is the resolution?
2. **Mathematics:** Students find the area of different shapes by decomposing them into triangles.
3. **Science:** Students research the different organs in order to understand how the human body digests food.
4. **Social Studies:** Students explore a different culture by studying the traditions, history and norms that comprise it.
5. **Languages:** Students learn about sentence structure in a foreign language by breaking it down into different parts like subject, verb and object.
6. Arts: Students work to build the set for a play by reviewing the scenes to determine their setting and prop needs.

Examples of Decomposition in Everyday Life 2/3

Birthday Party: Preparing the cake requires you to buy ingredients, make the cake, then frost it. You do similar decomposition for preparing snacks and games.

Making a Quiz: Decompose the project into parts such as the questions, the artwork for the background and the score.

Bicycles: Understanding how a bicycle works is more straightforward if the whole bike is separated into smaller parts and each part is examined to see how it works in more detail.

Science: The water cycle is explained through a sequences of processes, from evaporation to infiltration.

Social Studies: Drawing a map involves calculating scale, grids and legends.

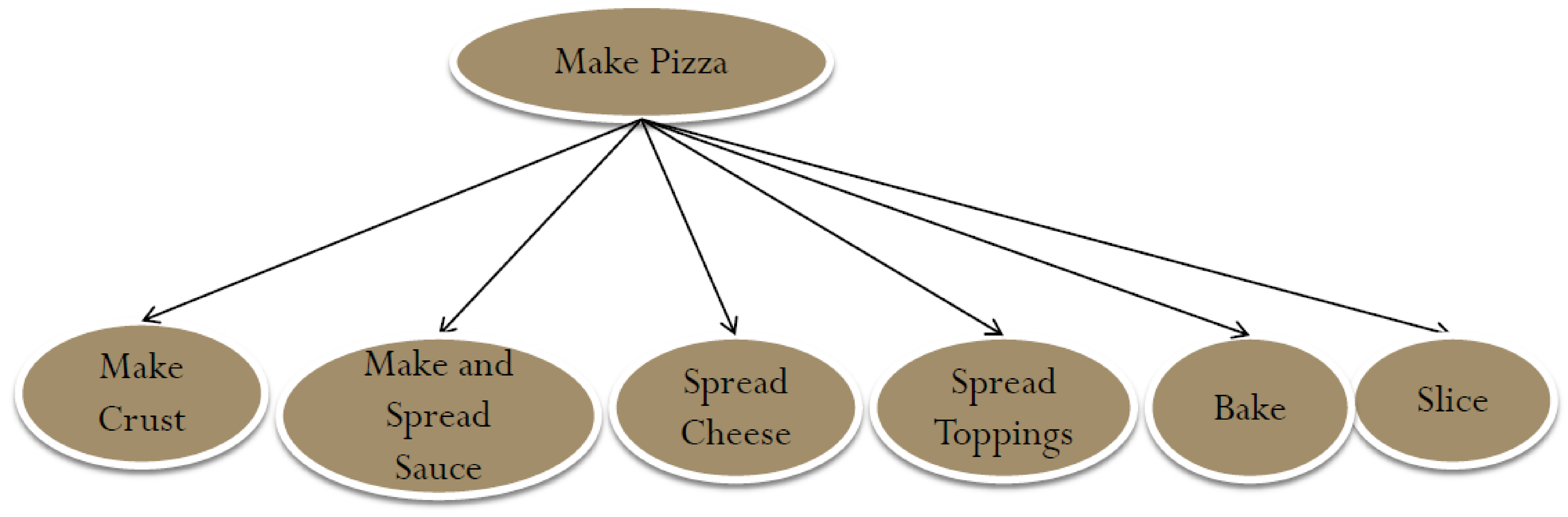
Mathematics: Solving individual components of quadratic equation.

Music: Identifying a piece of music by recognizing individual components from a composer.

English: Break down the analysis of a poem into analysis of meter, rhyme, imagery, structure, tone, diction, and meaning.

Visual Arts: Producing a short film requires planning the writing, acting, filming, and editing.

Examples of Decomposition in Everyday Life 3/3

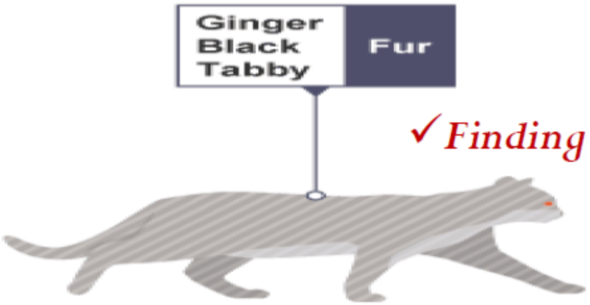


External Sources

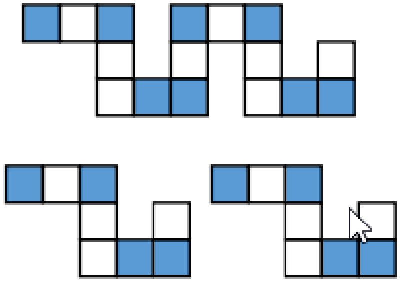
Videos

1. https://www.youtube.com/watch?v=yQVTijX437c
2. https://www.youtube.com/watch?v=spvupc-GgnE

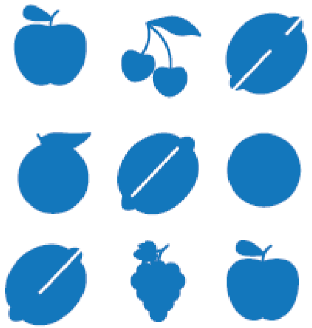
II. Pattern recognition



✓ *Finding patterns is extremely important*



Pattern recognition



Once you have decomposed a complex problem, it helps to examine the small problems for similarities or "patterns".

These patterns can help you to solve complex problems more efficiently.

When you decompose a complex problem, you often find patterns among the smaller problems you create.

The patterns are similarities or characteristics that some of problems share.

It involves finding similarities or patterns among small, decomposed problems that can help us solve more complex problems more efficiently.

Identifying patterns and trends in data using them to make predictions or generalizations. "Lets one object stand for many".

The more patterns you can find, the easier and quicker our overall task of problem solving will be.

To find patterns in problems you look for things that are the same (or very similar) in each problem

Examples of Pattern Recognition in Everyday Life 1/3

Driving: In driving, we use pattern recognition to predict and respond to different traffic patterns processes. For instance, we may recognize that an upcoming timed traffic light has turned yellow. We know that the pattern of process at the timed lights in the area is for the cross-traffic turn lanes to turn next, then straight cross-traffic, the turn lanes in our direction, then finally our light will turn green. We automatically process this pattern and can reasonably predict how much time we have before the light will turn green.

Medicine: Pattern recognition is prominent in medicine, where identifying patterns helps to diagnose and cure diseases as well as to understand and prevent disease. When a patient discusses symptoms with a doctor or undergoes a series of tests, the results are compared against known patterns to quickly identify types of infections or injuries that may be causing the symptoms and to apply corresponding solutions to the diagnoses. New diseases can also be categorized and have cures, treatments, or preventions identified based on pattern recognition from other corresponding medical complications.

Mathematical formulas: One example of pattern recognition in everyday life is in mathematical formulas that we may use regularly, such as for tipping, converting measurements, determining mpg of a vehicle, etc. All mathematical formulas are a result of and used in pattern recognition and algorithmic thinking. Formulas were created after patterns were identified and applied to create a common solution. Comparably, formulas can be used in mathematics by using pattern recognition to identify situations in which a particular formula may or may not be useful.

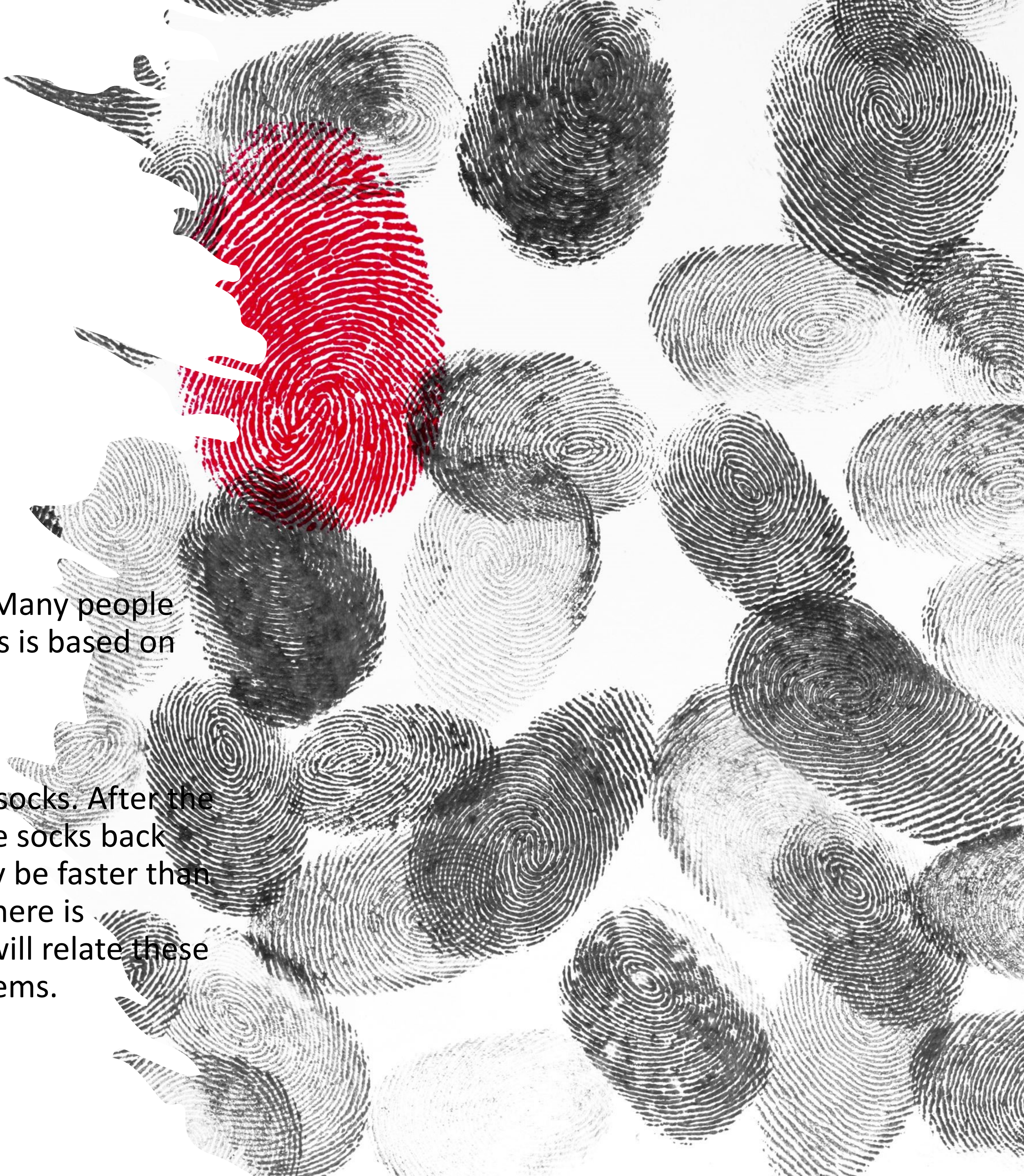
Examples of Pattern Recognition in Everyday Life 2/3

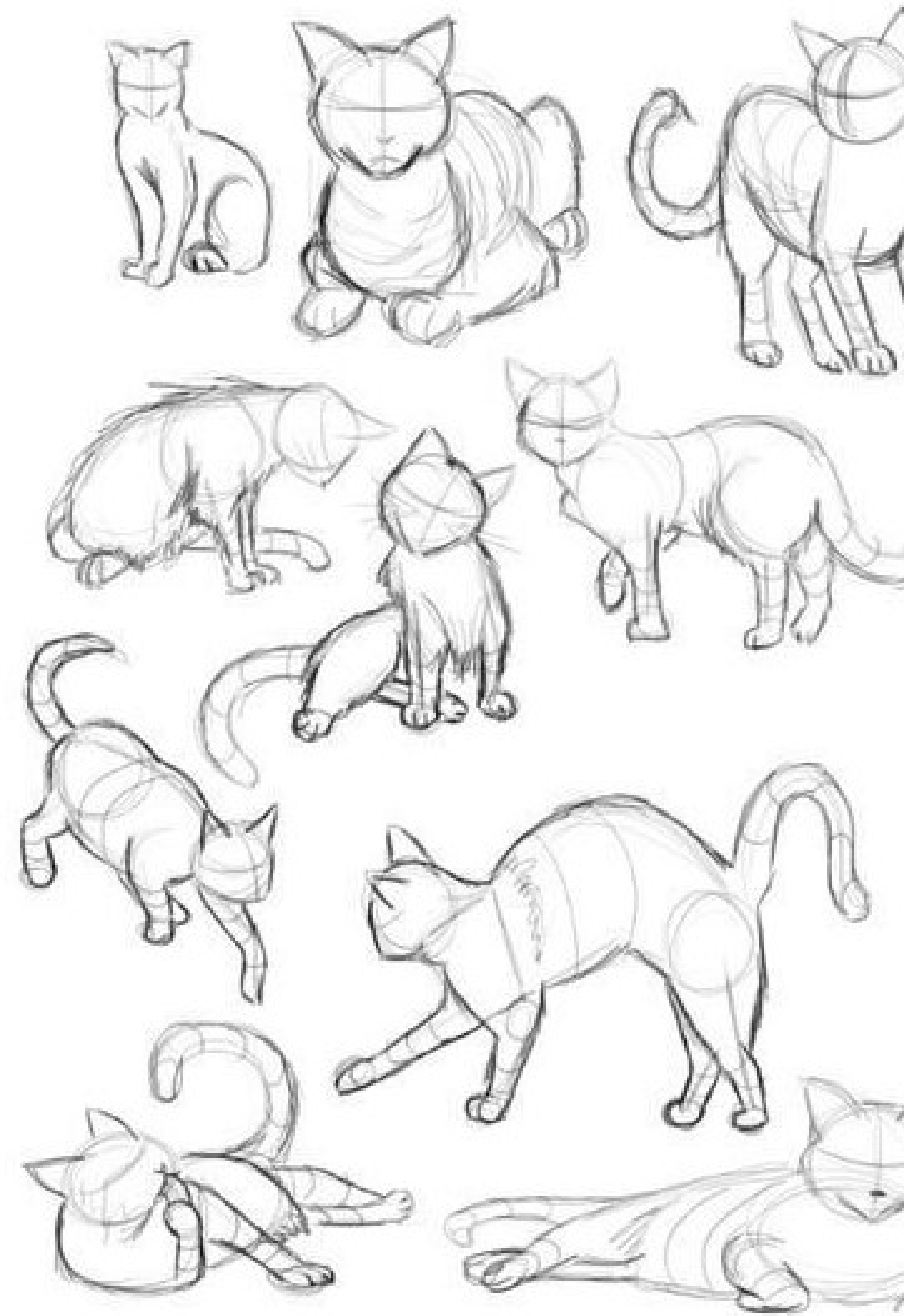
Can you spot the sequence in these numbers ?

{ 1,4,7,10,13,16,19,22,25,… }

How does pattern recognition work on images or photographs: Many people use face recognition in photos when posting to social media. This is based on pattern recognition, similar to fingerprints.

Everyone of us has done laundry, with all your clothes including socks. After the socks have dried, you use pattern recognition in order to pair the socks back together. Although there is an algorithm where one method may be faster than another, pattern matching is a key to com posing the solution. There is similarities to finding a shirt of your size in a clothing store. We will relate these examples to modern solutions that deal with many more data items.





Examples of Pattern Recognition in Everyday Life 3/3

Text Compression (English Language): Computers store and enormous amount of data and in so doing they utilize algorithms that simply use pointers or markers instead of repeated lines of text or data. This helps the system storage by decreasing file size and also utilizes routines that are more efficient in processing. We see this in compression of text files, photos and videos, and often the computers will compress when doing backups. The latest iteration of Google Drive call Drive File Streaming is a prime example of how this can be applied to our entire datastore. In this activity we will engage participants in a text compression exercise.

Drawing Cats: Draw a series of animals. What are the patterns we can recognize? All cats have similar characteristics. All cats have a tail, eyes and fur, and also eat fish and meow. These general characteristics are called patterns when looking through the lens of computational thinking. Now from this general knowledge of patterns in cats, we could draw the general outline of a cat.

External Sources

Videos

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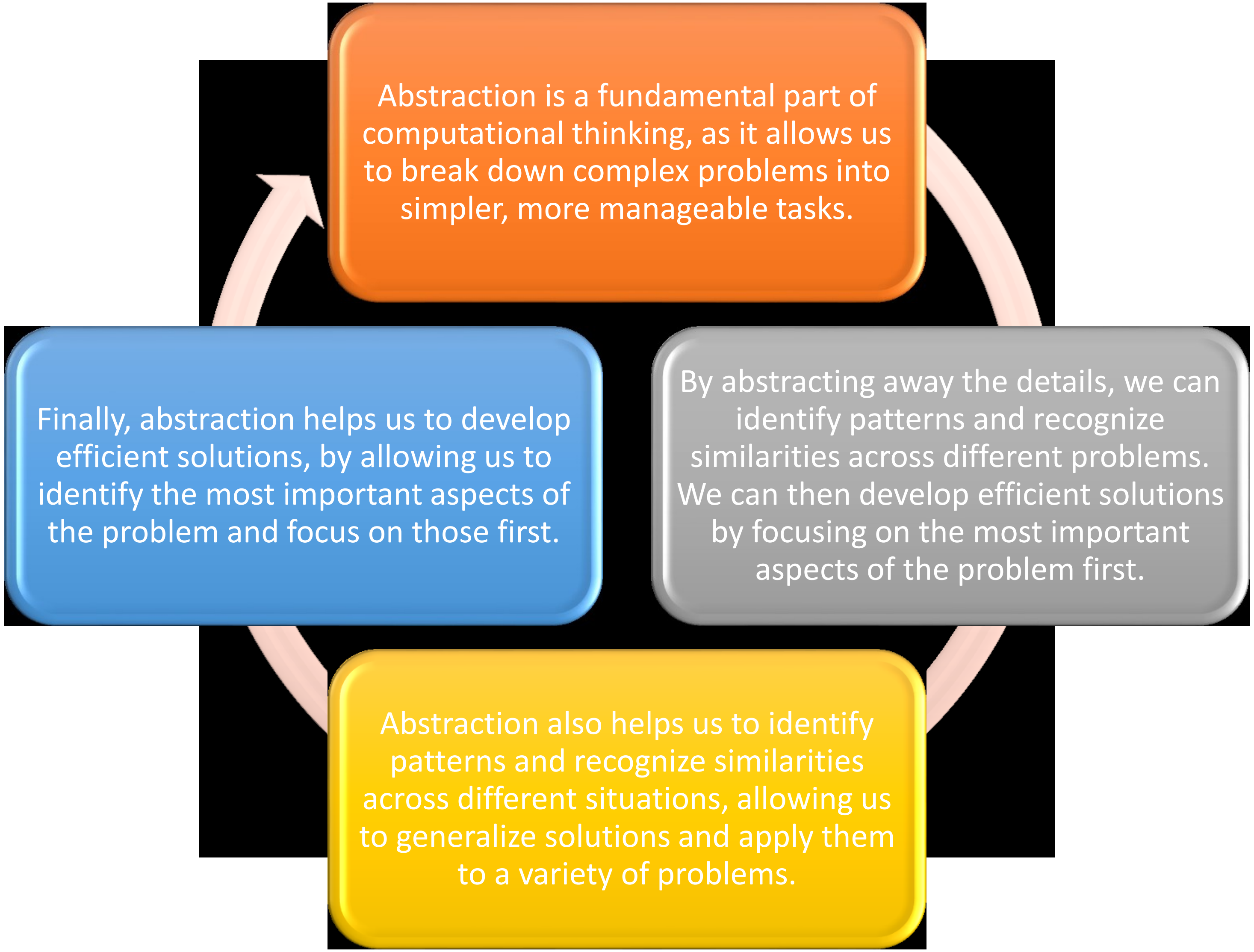
3. https://www.funbrain.com/games/number-cracker-game

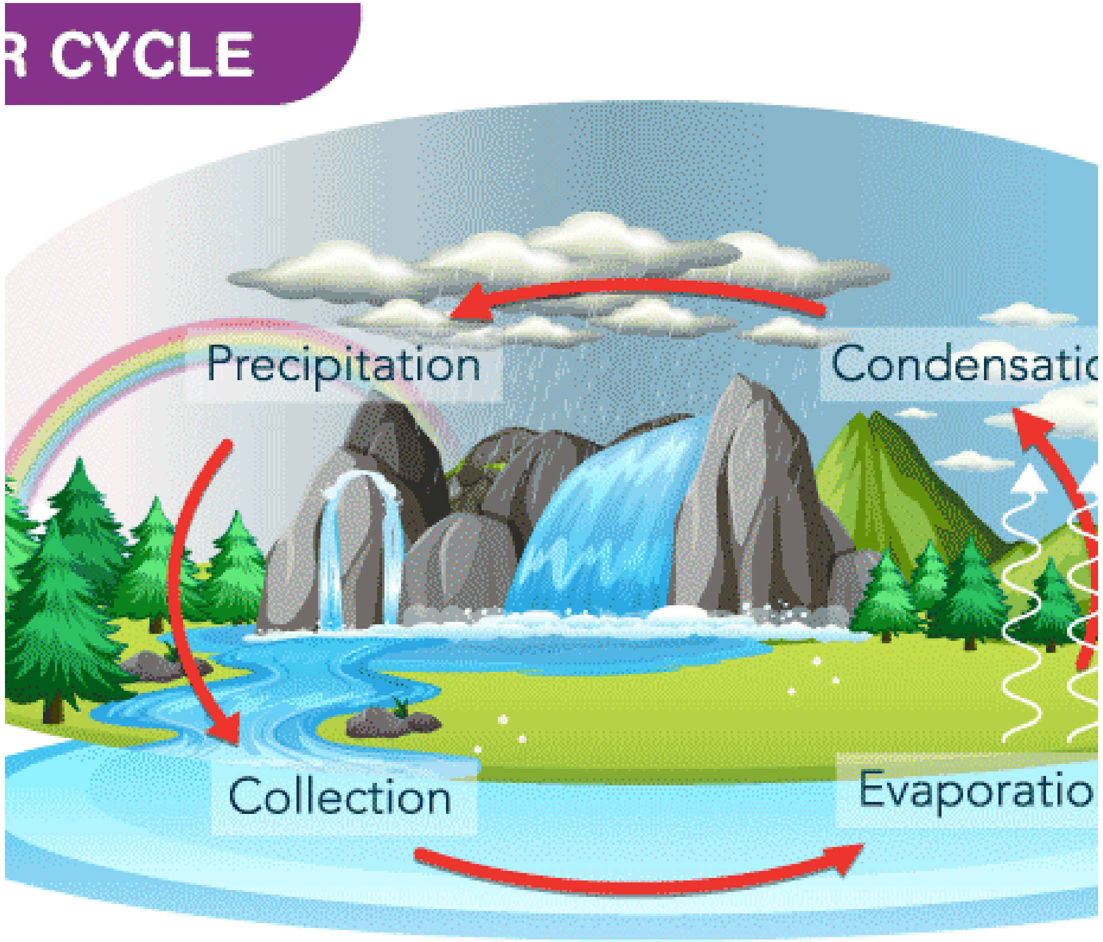
III. Abstraction

Abstraction



Examples of Abstraction in Everyday Life

- **Transit Maps:** When we analyze a transit map we omit unnecessary data (geographic accuracy, street names, topography) to allow the user to focus on the important facts (station names, transfer stations, different routes).
- **Data Representation:** If I say the words ‘tree’ and 'root' you know what those represent. However, I could be talking about an elm tree or a directory tree. The abstraction helps us communicate and think about the way our data is accessed
- **Driving to work:** There are intricate workings inside the motor that make your vehicle move However, aside from “start engine, engage drive and use gas and brake pedals,” these intricacies are largely ignored when you drive to work.
- **Simplified models** of the water cycle, nitrogen cycle, rock cycle
- The **Periodic Table** is an abstract diagram representing lots of information about human knowledge on earth’s materials



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Videos

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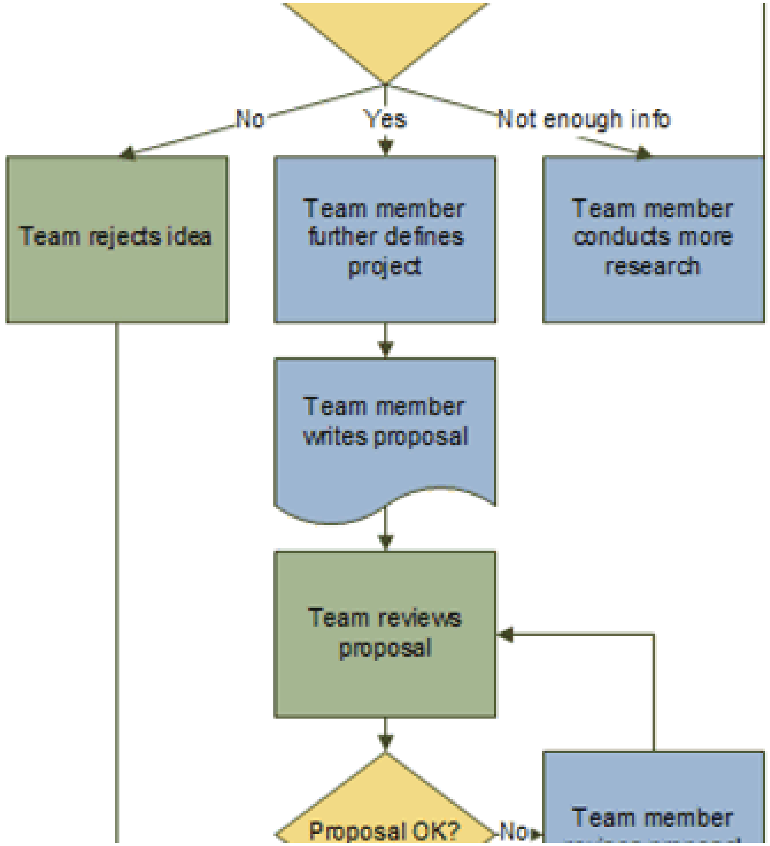
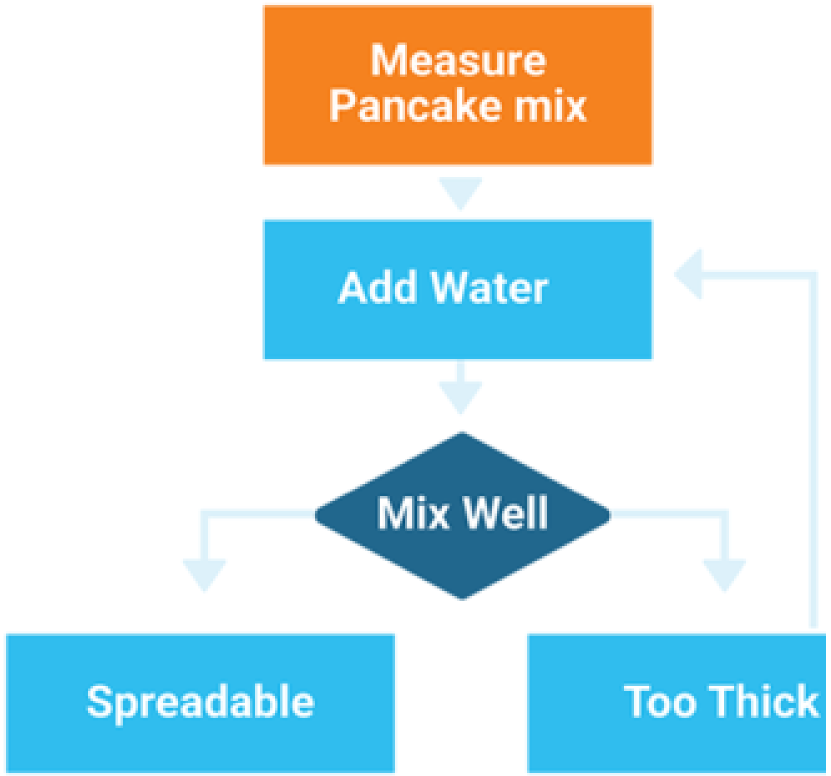
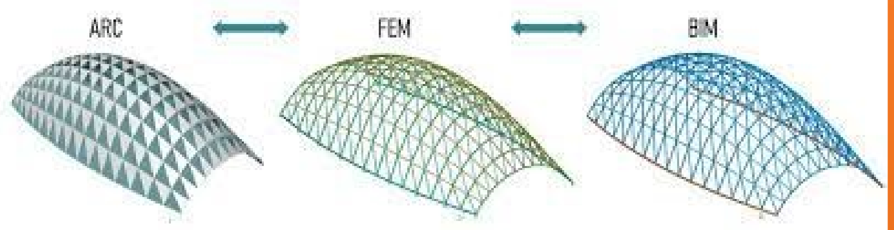
IV. Algorithm design





Algorithms



Algorithm design in computational thinking is the process of designing a step-by-step set of instructions that can be used to solve a problem. This involves breaking down a problem into smaller, manageable parts and then creating a sequence of instructions that can be used to solve it. Algorithm design requires the use of sound problem-solving methods, algorithmic logic, and computational thinking skills. Examples of algorithm design include:

- 1. Search algorithms: These algorithms are used to search for and find a specific item or solution in a large data set.
- 2. Sort algorithms: These algorithms are used to sort items in a specific order.
- 3. Optimization algorithms: These algorithms are used to find the optimal solution to a problem.
- 4. Pathfinding algorithms: These algorithms are used to find the shortest path between two points.

- **Evaluation and testing:** Testing and evaluating an algorithm involves running it through a variety of tests to ensure that it works correctly and produces the desired result. This process includes testing the algorithm on different types of data, testing for edge cases, and testing for errors. It also involves evaluating the performance of the algorithm and making sure that it is efficient and effective. Examples of testing and evaluating an algorithm include:

  1. Sanity checking: This involves running the algorithm on simple test cases to make sure it works correctly.
  2. Performance testing: This involves running the algorithm on larger datasets to make sure it is efficient and effective.
  3. Edge case testing: This involves testing the algorithm with extreme inputs to make sure it handles them correctly.
  4. Error testing: This involves testing the algorithm for potential errors and making sure it handles them correctly

Examples of Algorithms in Everyday Life

Recipe: A recipe is a set of instructions that describe how to make a dish. It's an algorithm that you follow step-by-step to produce a desired outcome.

GPS navigation: GPS navigation systems use algorithms to calculate the most efficient route between two points, taking into account factors such as traffic, road conditions, and distance.

Online shopping: Online shopping websites use algorithms to recommend products to users based on their browsing and purchasing history.

Music streaming: Music streaming services use algorithms to generate playlists based on a user's listening history, musical preferences, and mood.

Social media: Social media platforms use algorithms to show users relevant content, such as posts from friends and accounts they follow, advertisements, and news articles, based on their browsing and engagement history.

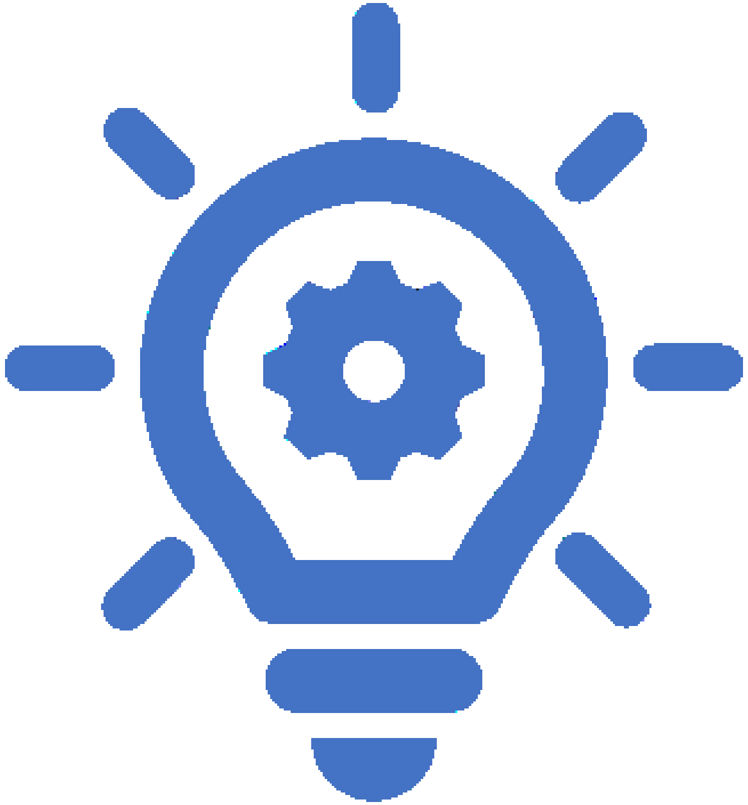
External Sources

Videos

1. https://www.youtube.com/watch?v=N91oCQbWUvA
2. https://www.youtube.com/watch?v=DHFeZNwtYAc

The Definition of a problem

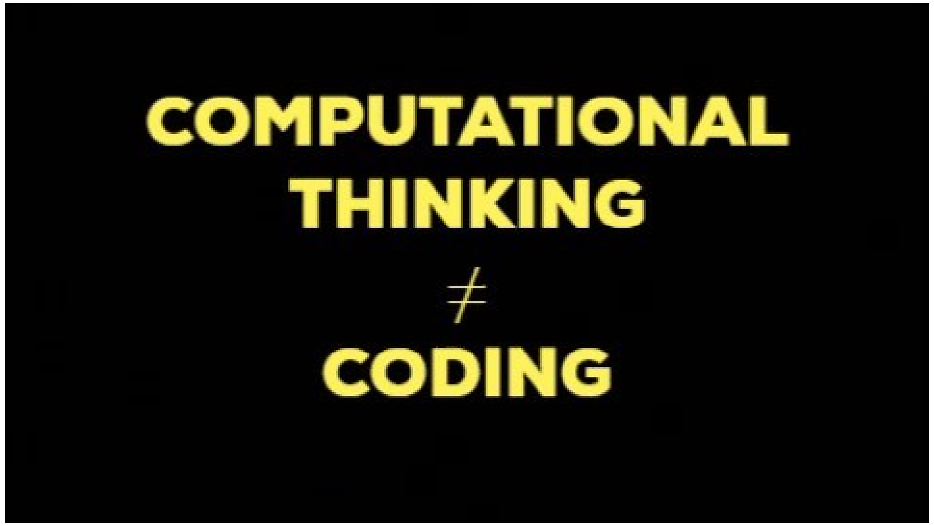
- In computational thinking, a problem refers to a situation or challenge that requires the use of computational methods or techniques to sc or achieve a specific goal or outcome. A problem in computatic thinking can be defined as a specific task or set of tasks that need tc completed using a computer or other information processing syst such as a phone or tablet.
- Problems in computational thinking are characterized by tl complexity, ambiguity, and the need for decomposition, patt recognition, abstraction, and algorithms to solve them. They can found in a wide range of fields, including computer scier mathematics, engineering, science, and business.
- Problems in computational thinking typically involve breaking dc complex systems into smaller, manageable parts and then us algorithms, data structures, and other computational methods to sc them. The process of solving a problem in computational thinl often involves the use of logical reasoning, mathematical analysis, other analytical techniques to understand and solve the problem.

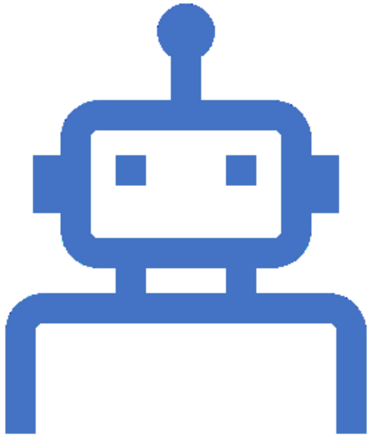


- It is possible for a problem in computational thinking to have none, one, or multiple solutions.
- A problem may have no solutions if it is impossible to solve or if there are too many constraints that cannot be met. In this case, the prob is considered to be unsolvable.
- A problem may have one solution if there is a clear and unique solu that can be found using computational methods. In this case, problem is considered to be well-defined.
- A problem may have multiple solutions if there are different way solve the problem and many possible outcomes. In this case, problem is considered to be ill-defined.
- It's important to note that, when a problem has multiple solutions, important to evaluate the trade-offs and the best approach to solve problem. Sometimes, there will be a best solution which is the one is more efficient, more reliable, or less expensive than other soluti And other times, there will be a solution that is better suited fo specific context or use case.

Coding vs Computational Thinking

- Coding and computational thinking are closely related concepts.
- Computational thinking is a way of thinking that involves breaking down complex problems into smaller, manageable pieces and finding solutions to those problems using algorithms, data, and other tools.
- Coding is the process of creating these algorithms and solutions using a programming language.
- In other words, computational thinking involves thinking like a computer, and coding is the process of turning those thoughts into action.
- Coding is one way to apply computational thinking, but it is not the only way. Computational thinking can also be applied in other fields, such as data analysis, engineering, and even the arts.
- Overall, computational thinking and coding are important skills to have in the digital age, as they allow you to think critically and solve problems in a logical and systematic way.





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