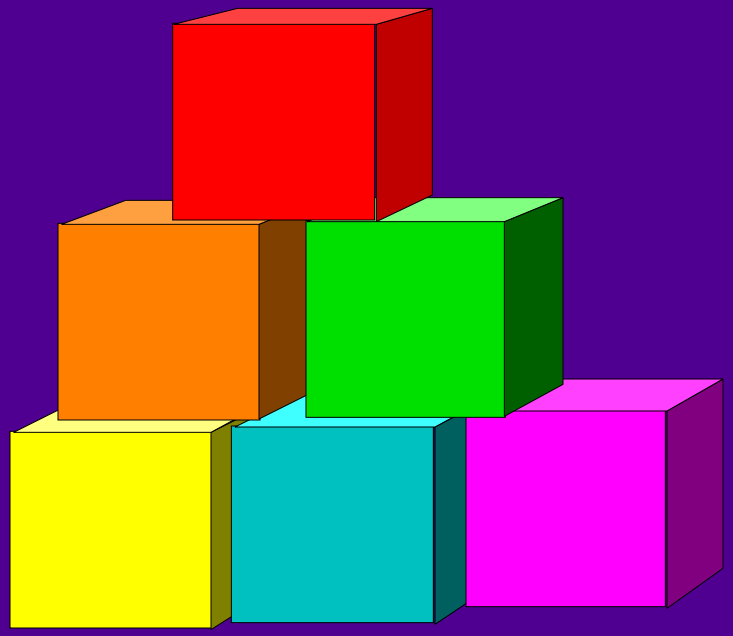
Teaching Problem Solving and Design



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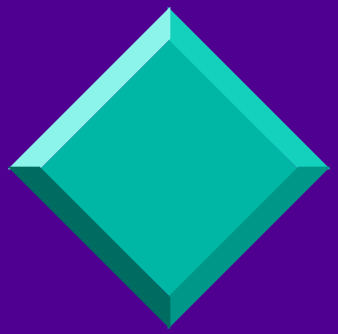
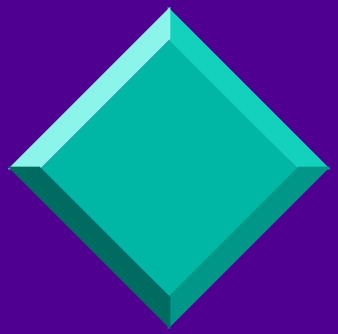
University of Toronto



The Goal

A primary goal of curriculum reform is to create classrooms in which students:

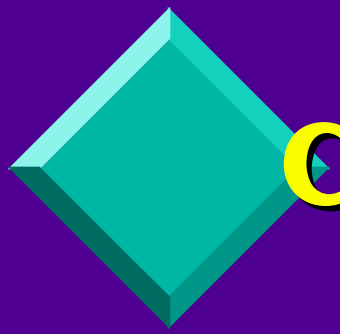
- are challenged to think critically
- learn how to discover, understand, and analyse
- apply skills and knowledge in new situations



The Reality

The majority of teachers pay little attention to problem solving in classroom instruction despite the fact that:

- these skills are documented as essential for college and university
- these skills are documented as essential for the workplace



Computer Programming

- Problem solving skills are absolutely key to program development.
- The most fundamental obstacles to learning to program are related to problem solving.

BUT!!!

- Most courses still focus on syntax!

Problem Solving Elements

Research has identified two basic kinds of problems:

- transformational problems where a set of operators are defined and applied to produce a solution
- synthesis problems where known components are selected and integrated to achieve a desired goal

Changing Paradigms

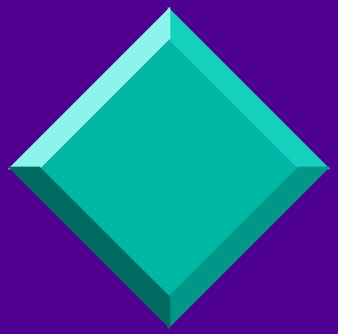
Programming problems used to be viewed exclusively as transformational problems but object oriented programming, reusable modules, software code libraries, and machine independent (portable) code are changing the very nature of programming.

Early Models of Problem Solving

The first problem solving models broke down into two distinct approaches:

- the traditional scientific method
- an introspective creative method

Scientists often report using both methods to enable discovery.



The Scientific Process

Dewey (1910):

- define the problem
- suggest possible solutions and identify alternative
- reason about the solutions and implement
- test and prove

The Creative Process

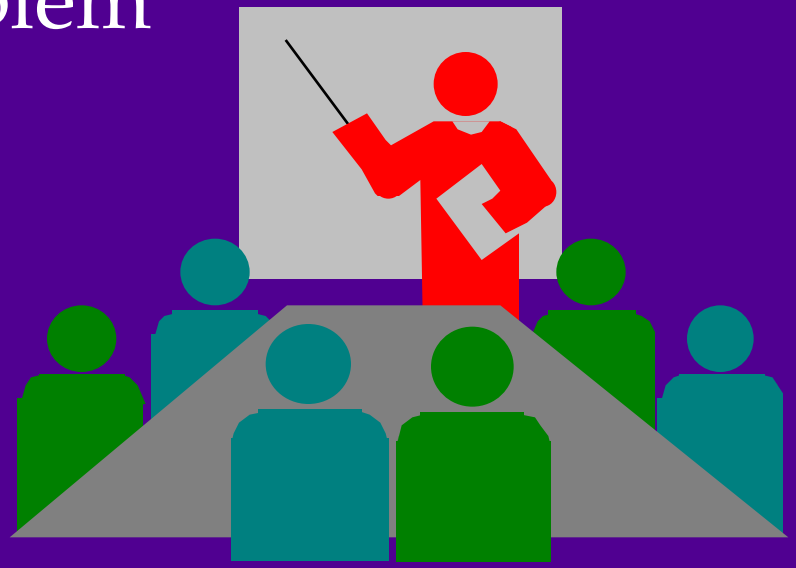
Wallas (1926):

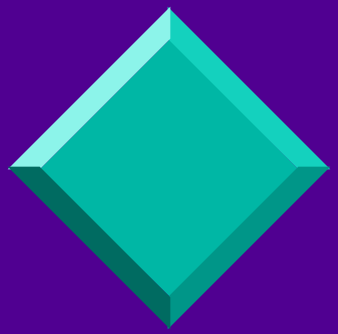
- problem formulation and information gathering
- incubation - allowing the unconscious to work on it
- illumination - working to gain insight
- verification - testing for accuracy

Classroom Model

Polya (1945 and 1962) was the first to describe a problem solving model based on classroom experience:

- understand the problem
- devise a plan
- carry out plan
- look back

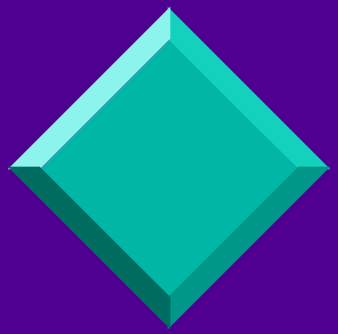




Polya's Model: Part 1

Understand the problem -

- state the question
- identify the goal
- give knowns, unknows and conditions
- introduce drawings or notations



Polya's Model: Part 2

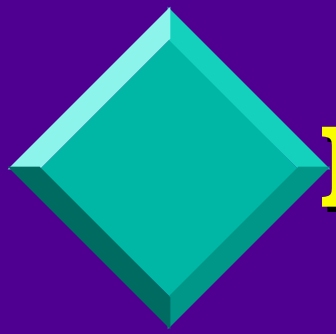
Devise a plan -

- outline a potential solution
- look at similar problems
- restate the problem differently
- break it into subproblems

Polya's Model: Part 3

Carry out plan -

- refine and transform into a solution
- relate tasks to givens and unknowns
- check validity of each step
- define steps in relations to the whole problem



Polya's Model: Part 4

Look back -

- confirm results and arguments
- assess effectiveness of solution
- assess accuracy of results
- assess usefulness of solution for solving other problems

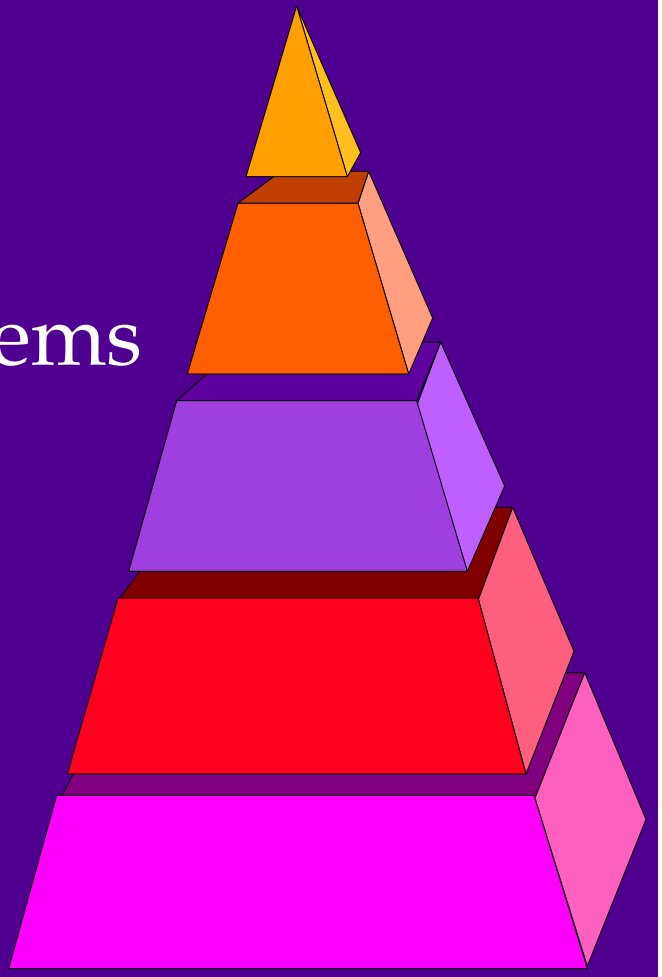
The Engineering Model

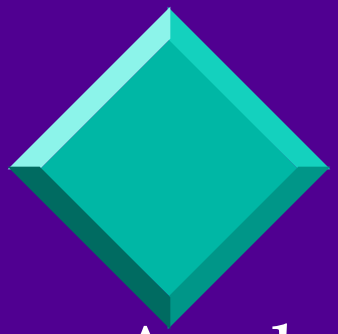
Etter (1995) presented a model used by students to solve engineering problems.

- define the problem - state it clearly
- gather information - describe input and output
- generate and evaluate potential solutions
- refine and implement solutions
- verify and test solution method and result

Students Need to Know

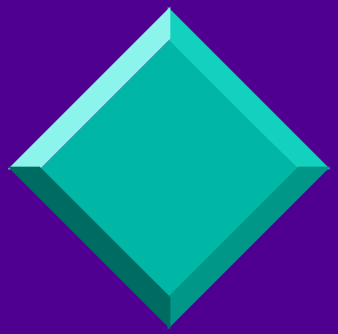
- What programming is
- The importance of style
- How computers solve problems
- How programmers develop software
- Software development over time





Programming is…

- Analyzing a problem to be solved.
- Preparing a design for the steps in a set of instructions (an algorithm)
- Expressing the algorithm in a language that the computer can ultimately execute.
- Providing adequate documentation
- Testing and validating the program
- Maintaining the program over time

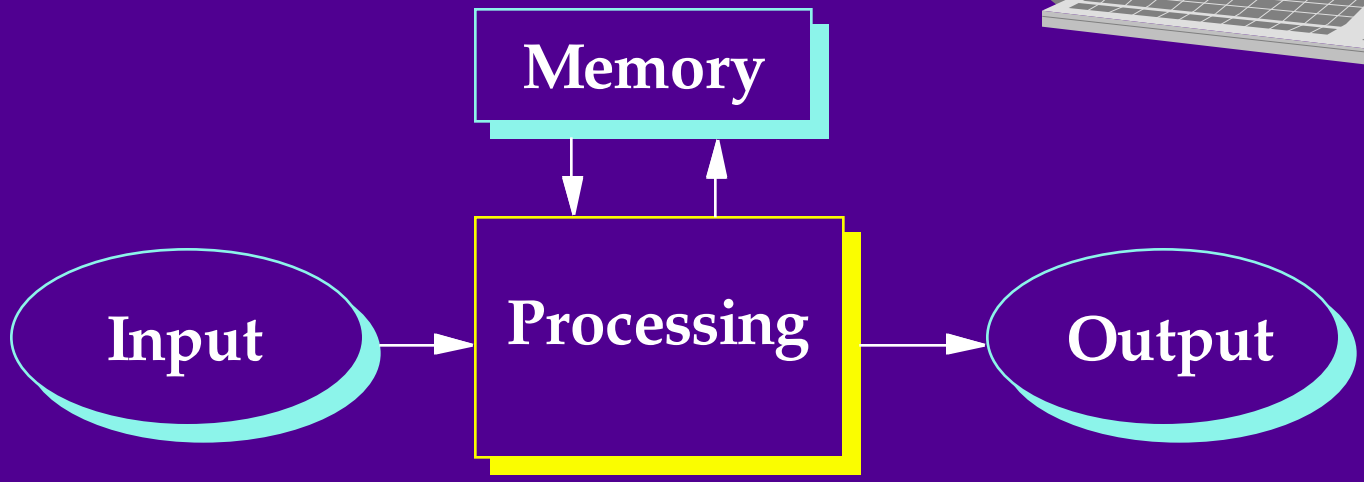


Elements of Style

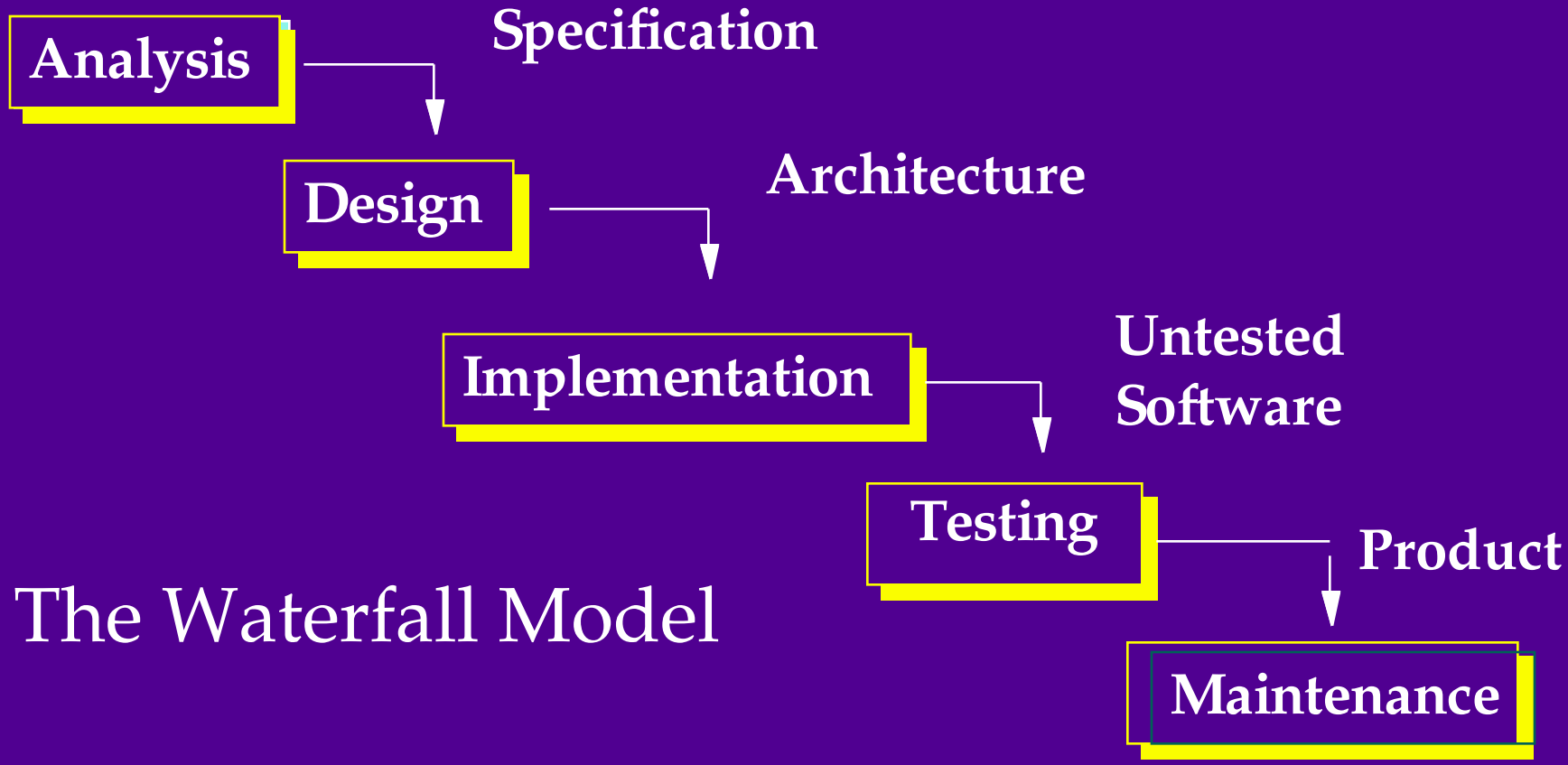
Good programming style is the foundation of well-designed programs.

- informative headers
- comments and variable descriptions
- useful variable names
- indentation to indicate structure

How Computers Solve Problems

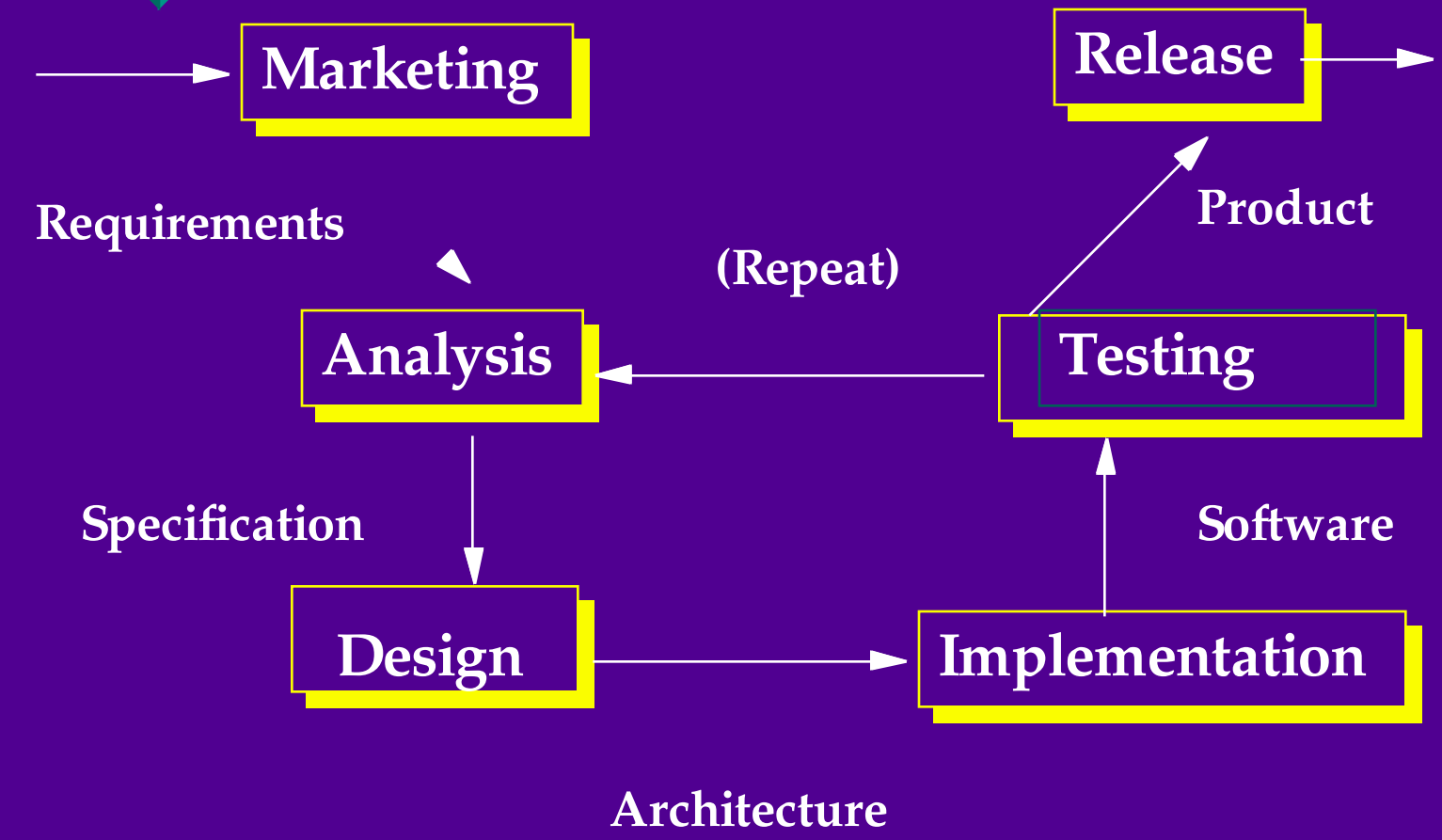


Software Development



The Waterfall Model

Iterative Model



Methodology

The most common methods used for teaching problem solving and critical thinking skills are:

- hands-on experience
- real world problems
- cooperative learning