

COMPUTATIONAL THINKING

A PROBLEM-SOLVING TOOL
FOR EVERY CLASSROOM

By: Pat Phillips



Microsoft®

What is computational thinking?

Computational thinking is integrating the power of human thinking with the capabilities of computers.

The essence of computational thinking is thinking about data and ideas, and using and combining these resources to solve problems. Teachers can encourage students to “think computationally” by moving technology projects beyond “using” tools and information toward “creating” tools and information.

The creation of tools and new information requires thought processes about manipulating data, using abstractions, and lots of computer science concepts. To encourage computational thinking in the classroom teachers must ask different questions related to problem solving and the use of technology. They must ask:

- What are the power and limit of human and computer intelligence?
- How difficult is the problem?
- How can it be solved?
- How can technology be applied to the problem?
- What computational strategies might be employed?

Because simulations can encourage students to think about data and ideas, and about using and combining data and ideas to solve problems, simulations are helpful to engage students in computational thinking. Simulations that encourage students to think computationally often require a mathematical representation of the problem—like a story problem, and mental modeling with the symbols and processes of other disciplines. Computational thinking is a required skill for 21st Century success which teachers can foster using subject-specific simulations and modeling. Learning activities that allow students to discover and explain scientific relationships, predict events, and learn procedural skills will enable them to better understand these subjects, to predict behavior, and to build computational thinking skills.

NOTE: The following pages of this document were originally printed and cut into individual cards for each discipline. Computer science and technology teachers at the CS & IT Symposium 2008 were urged to distribute the cards to fellow teachers who taught mathematics, science, computer science, social studies, language arts, and the fine arts, and to encourage the use simulations and modeling as a way to develop computational thinking skills across the disciplines.

csta.acm.org/Resources/sub/highlightedResources.html



COMPUTATIONAL THINKING IN COMPUTER SCIENCE

AGENTSHEETS

A computational science authoring tool
scalablegamedesign.cs.colorado.edu

ALICE

Programming language based on Standard ML
www.ps.uni-sb.de/alice/

BEGINNER DEVELOPER LEARNING CENTER FROM MICROSOFT®

msdn.microsoft.com/vstudio/express/beginner/

COMPUTER SCIENCE 4 FUN

www.cs4fn.org/

COMPUTER SCIENCE-IN-A-BOX

Teach computational concepts without a computer
www.ncwit.org/unplugged

COMPUTER SCIENCE TEACHERS ASSOCIATION

The primary resource for all CS teachers
csta.acm.org/

COMPUTER SCIENCE UNPLUGGED

csunplugged.com/

INTRODUCTION TO MEDIA COMPUTATION

A media-based path into computer science
coweb.cc.gatech.edu/mediaComp-plan

PHROGRAM

A programming environment for kids
phrogram.com/

PRE-COLLEGIATE FACULTY CONNECTION FROM MICROSOFT®

[www.microsoft.com/education/facultyconnection/
precollegiate](http://www.microsoft.com/education/facultyconnection/precollegiate)

SCRATCH FROM LIFELONG KINDERGARTEN

Easy to learn programming for children
scratch.mit.edu/

THE INTEGRATED CIRCUIT

http://nobelprize.org/educational_games/physics/

COMPUTATIONAL THINKING IN PHYSICAL SCIENCES

CONCORD CONSORTIUM

Free software for analyzing and manipulating data
www.concord.org/resources/browse/172/

GALILEO'S EXPERIMENTS

www.pbs.org/wgbh/nova/galileo/

GEOLOGY LABS AND EARTHQUAKE SIMULATIONS

nemo.sciencecourseware.org/

LASER CHALLENGE

nobelprize.org/educational_games/physics/laser/

MICROSOFT® FLIGHT SIMULATOR X

Free trial with 2 airports, 2 missions, and 3 aircraft
www.microsoft.com/games/pc/flightsimulatorx.aspx

Information for educators

www.fsinsider.com/product/Pages/InfoEducators.aspx

NATIONAL COMPUTATIONAL SCIENCE INSTITUTE

Resources for teachers and students
computationalscience.org

NETLOGO USER COMMUNITY MODELS

A wide variety of simulations
ccl.northwestern.edu/netlogo/models/community/

ONLINE MATH APPLICATIONS FOR SCIENCE

library.thinkquest.org/4116/Science/science.htm

SCIENCE ANIMATIONS, MOVIES, AND INTERACTIVE TUTORIALS

An extensive list from dozens of sources
nhscience.lonestar.edu/biol/animatio.htm

UNDERSTANDING SCIENCE THROUGH COMPUTING

A Web site from the U.S. Department of Energy
ascr-discovery.science.doe.gov/

COMPUTATIONAL THINKING IN MATHEMATICS

CONCORD CONSORTIUM

Free Software for analyzing and manipulating data
www.concord.org/resources/browse/172/

eNLVM INTERACTIVE ONLINE MATH LESSONS

Lessons with teacher-supplied plans
enlvm.usu.edu/ma/nav/bb_school.jsp?sid=emready&coid=all

EXPLORATION OF PROJECTILE MOTION AND AIR RESISTANCE

csip.cornell.edu/curriculum_resources/

INTERACTIVE MATHEMATICS

www.cut-the-knot.org/index.shtml

MATH FORUM

A wealth of problems and puzzles, team problem-solving, collaborations, and professional development
mathforum.org/

MATH STANDARDS

By grade level with modeling activities
standards.nctm.org/document/eexamples/index.htm

MATHEMATICS GIZMOS

www.explorelearning.com/

NATIONAL LIBRARY OF VIRTUAL MANIPULATIVES

By grade level aligned to standards
nlvm.usu.edu/en/nav/topic_t_1.html

ONLINE MATH APPLICATIONS

library.thinkquest.org/4116/Science/science.htm

TOPOLOGY AND GEOMETRY SOFTWARE

www.geometrygames.org/

COMPUTATIONAL THINKING IN SOCIAL STUDIES

ATLAS OF U.S. PRESIDENTIAL ELECTIONS

uselectionatlas.org/

CONCORD CONSORTIUM

Community Planner
www.concord.org/resources/browse/251/

CORNROW HAIR BRAIDING

The history, culture, and transformational geometry with interactive software
www.ccd.rpi.edu/Eglash/csdt/african/CORNROW_CURVES/cornrow_homepage.html

DISCOVERY CHANNEL INTERACTIVES

Your Digital Footprint and many more
dsc.discovery.com/games/games-tab-04.html

JUNK CHARTS

Analyzing data representations
junkcharts.typepad.com/

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM)

Census data analysis with spreadsheets
standards.nctm.org/document/eexamples/chap5/5.4/index.htm

ONLINE MATH APPLICATIONS: INVESTING

library.thinkquest.org/4116/Investing/investin.htm

POLLING GIZMOS

Inferences and predictions
www.explorelearning.com/

PROJECTS FROM LIFELONG KINDERGARTEN

llk.media.mit.edu/projects.php

COMPUTATIONAL THINKING IN LANGUAGE ARTS

A SIDE OF SIMS

Suggestions for the Classroom

A sampling of simulations for elementary, middle, and high school

www.edutopia.org/node/3343

BLOGMARKS

A collection of many language arts tools and simulations

blogmarks.net/marks/tag/sms%253Alanguage%2Barts

CONCORD CONSORTIUM

Video Paper Builder (English and Spanish)

www.concord.org/resources/browse/172/

DIGITAL LITERACY

Skills for the 21st Century

"We have to get used to thinking of images, sounds and movement as raw material for construction...Students have to learn to think about the purposes for which they want to use different media when they are authoring a multimedia text."

www.edc.org/CCT/dig_lit/web/index.html

JUNK CHARTS

Analyzing data representations

junkcharts.typepad.com/

STAGECAST

Students build and script their own simulations

www.stagecast.com/index.html

COMPUTATIONAL THINKING IN FINE ARTS

COLORJACK

A powerful color wheel simulation

www.colorjack.com/

CRAFT TECH

Software to design and construct crafts such as mechanical toys and paper sculpture

13d.cs.colorado.edu/~ctg

CRICKETS

Create musical sculptures, interactive jewelry, and artistic inventions while learning math, science, and engineering

www.picocricket.com/

DIGITAL LITERACY

Explorations with graphics and sounds

www.edc.org/CCT/dig_lit/web/index.html

INTRODUCTION TO MEDIA COMPUTATION

A media-based path into computer science

coweb.cc.gatech.edu/mediaComp-plan

ONLINE MATH APPLICATIONS: MUSIC

library.thinkquest.org/4116/Music/music.htm

PERFECT PITCH FROM THE KENNEDY CENTER

Create an orchestra and experiment with instruments and compositions

www.artsedge.kennedy-center.org/perfectpitch/

THE PERCEPTION DECEPTION

www.cs4fn.org/illusions/

COMPUTATIONAL THINKING IN LIFE SCIENCES

BIOLOGY LABS ONLINE

nemo.sciencecourseware.org/BLOL/

CONCORD CONSORTIUM

www.concord.org/resources/browse/172/

DISCOVERY CHANNEL INTERACTIVES

Ice Map, Earth Live and more

dsc.discovery.com/games/games-tab-04.html

ONLINE MATH APPLICATIONS: SCIENCE

library.thinkquest.org/4116/Science/science.htm

PHASE CONTRAST MICROSCOPE SIMULATION

nobelprize.org/educational_games/physics/imaginglife/index.html

PhET INTERACTIVE SIMULATIONS

A wide variety of science simulations

phet.colorado.edu/index.php

SCIENCE ANIMATIONS, MOVIES & INTERACTIVE TUTORIALS

nhscience.lonestar.edu/biol/animatio.htm

SMITHSONIAN MUSEUM OF NATURAL HISTORY

www.mnh.si.edu/education/classroom_resources/studentactivities/index.html

COMPUTATIONAL THINKING FURTHER READING

BEGINNER DEVELOPER LEARNING CENTER FROM MICROSOFT®

Bits & Bytes and Kid's Corner

msdn.microsoft.com/en-us/beginner/default.aspx

CENTER FOR COMPUTATIONAL THINKING

Sponsored by Microsoft® Research

www.cs.cmu.edu/~CompThink/

COMPUTATIONAL THINKING

Jeannette M. Wing, CMU

www.cs.cmu.edu/afs/cs/usr/wing/www/publications/Wing06.pdf

COMPUTATIONAL THINKING

IAE-pedia - A free education-oriented encyclopedia

iae-pedia.org/Computational_Thinking

COMPUTATIONAL THINKING PATTERNS

See the possibility of computational representation in situations

scalablegamedesign.cs.colorado.edu/wiki/Computational_thinking

GREAT PRINCIPLES OF COMPUTING

Peter J. Denning, Naval Postgraduate School

cs.gmu.edu/cne/pjd/GP/gp_overview.html