

# COMPUTATIONAL THINKING

A PROBLEM-SOLVING TOOL  
FOR EVERY CLASSROOM

By: Pat Phillips



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# 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 21<sup>st</sup> 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](http://csta.acm.org/Resources/sub/highlightedResources.html)



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# COMPUTATIONAL THINKING IN COMPUTER SCIENCE

## AGENTSHEETS

A computational science authoring tool  
[scalablegamedesign.cs.colorado.edu](http://scalablegamedesign.cs.colorado.edu)

## ALICE

Programming language based on Standard ML  
[www.ps.uni-sb.de/alice/](http://www.ps.uni-sb.de/alice/)

## BEGINNER DEVELOPER LEARNING CENTER FROM MICROSOFT®

[msdn.microsoft.com/vstudio/express/beginner/](http://msdn.microsoft.com/vstudio/express/beginner/)

## COMPUTER SCIENCE 4 FUN

[www.cs4fn.org/](http://www.cs4fn.org/)

## COMPUTER SCIENCE-IN-A-BOX

Teach computational concepts without a computer  
[www.ncwit.org/unplugged](http://www.ncwit.org/unplugged)

## COMPUTER SCIENCE TEACHERS ASSOCIATION

The primary resource for all CS teachers  
[csta.acm.org/](http://csta.acm.org/)

## COMPUTER SCIENCE UNPLUGGED

[csunplugged.com/](http://csunplugged.com/)

## INTRODUCTION TO MEDIA COMPUTATION

A media-based path into computer science  
[coweb.cc.gatech.edu/mediaComp-plan](http://coweb.cc.gatech.edu/mediaComp-plan)

## PHROGRAM

A programming environment for kids  
[phrogram.com/](http://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/](http://scratch.mit.edu/)

## THE INTEGRATED CIRCUIT

[http://nobelprize.org/educational\\_games/physics/](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/](http://www.concord.org/resources/browse/172/)

## GALILEO'S EXPERIMENTS

[www.pbs.org/wgbh/nova/galileo/](http://www.pbs.org/wgbh/nova/galileo/)

## GEOLOGY LABS AND EARTHQUAKE SIMULATIONS

[nemo.sciencecourseware.org/](http://nemo.sciencecourseware.org/)

## LASER CHALLENGE

[nobelprize.org/educational\\_games/physics/laser/](http://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](http://www.microsoft.com/games/pc/flightsimulatorx.aspx)

## Information for educators

[www.fsinsider.com/product/Pages/InfoEducators.aspx](http://www.fsinsider.com/product/Pages/InfoEducators.aspx)

## NATIONAL COMPUTATIONAL SCIENCE INSTITUTE

Resources for teachers and students  
[computationalscience.org](http://computationalscience.org)

## NETLOGO USER COMMUNITY MODELS

A wide variety of simulations  
[ccl.northwestern.edu/netlogo/models/community/](http://ccl.northwestern.edu/netlogo/models/community/)

## ONLINE MATH APPLICATIONS FOR SCIENCE

[library.thinkquest.org/4116/Science/science.htm](http://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](http://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/](http://ascr-discovery.science.doe.gov/)

# COMPUTATIONAL THINKING IN MATHEMATICS

## CONCORD CONSORTIUM

Free Software for analyzing and manipulating data  
[www.concord.org/resources/browse/172/](http://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](http://enlvm.usu.edu/ma/nav/bb_school.jsp?sid=emready&coid=all)

## EXPLORATION OF PROJECTILE MOTION AND AIR RESISTANCE

[csip.cornell.edu/curriculum\\_resources/](http://csip.cornell.edu/curriculum_resources/)

## INTERACTIVE MATHEMATICS

[www.cut-the-knot.org/index.shtml](http://www.cut-the-knot.org/index.shtml)

## MATH FORUM

A wealth of problems and puzzles, team problem-solving, collaborations, and professional development  
[mathforum.org/](http://mathforum.org/)

## MATH STANDARDS

By grade level with modeling activities  
[standards.nctm.org/document/examples/index.htm](http://standards.nctm.org/document/examples/index.htm)

## MATHEMATICS GIZMOS

[www.explorelearning.com/](http://www.explorelearning.com/)

## NATIONAL LIBRARY OF VIRTUAL MANIPULATIVES

By grade level aligned to standards  
[nlvm.usu.edu/en/nav/topic\\_t\\_1.html](http://nlvm.usu.edu/en/nav/topic_t_1.html)

## ONLINE MATH APPLICATIONS

[library.thinkquest.org/4116/Science/science.htm](http://library.thinkquest.org/4116/Science/science.htm)

## TOPOLOGY AND GEOMETRY SOFTWARE

[www.geometrygames.org/](http://www.geometrygames.org/)

# COMPUTATIONAL THINKING IN SOCIAL STUDIES

## ATLAS OF U.S. PRESIDENTIAL ELECTIONS

[uselectionatlas.org/](http://uselectionatlas.org/)

## CONCORD CONSORTIUM

Community Planner  
[www.concord.org/resources/browse/251/](http://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](http://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](http://dsc.discovery.com/games/games-tab-04.html)

## JUNK CHARTS

Analyzing data representations  
[junkcharts.typepad.com/](http://junkcharts.typepad.com/)

## NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM)

Census data analysis with spreadsheets  
[standards.nctm.org/document/examples/chap5/5.4/index.htm](http://standards.nctm.org/document/examples/chap5/5.4/index.htm)

## ONLINE MATH APPLICATIONS: INVESTING

[library.thinkquest.org/4116/Investing/investin.htm](http://library.thinkquest.org/4116/Investing/investin.htm)

## POLLING GIZMOS

Inferences and predictions  
[www.explorelearning.com/](http://www.explorelearning.com/)

## PROJECTS FROM LIFELONG KINDERGARTEN

[llk.media.mit.edu/projects.php](http://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](http://www.edutopia.org/node/3343)

## BLOGMARKS

A collection of many language arts tools and simulations

[blogmarks.net/marks/tag/sms%253Alanguage%2Barts](http://blogmarks.net/marks/tag/sms%253Alanguage%2Barts)

## CONCORD CONSORTIUM

Video Paper Builder (English and Spanish)

[www.concord.org/resources/browse/172/](http://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](http://www.edc.org/CCT/dig_lit/web/index.html)

## JUNK CHARTS

Analyzing data representations

[junkcharts.typepad.com/](http://junkcharts.typepad.com/)

## STAGECAST

Students build and script their own simulations

[www.stagecast.com/index.html](http://www.stagecast.com/index.html)

# COMPUTATIONAL THINKING IN FINE ARTS

## COLORJACK

A powerful color wheel simulation

[www.colorjack.com/](http://www.colorjack.com/)

## CRAFT TECH

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

[13d.cs.colorado.edu/~ctg](http://13d.cs.colorado.edu/~ctg)

## CRICKETS

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

[www.picocricket.com/](http://www.picocricket.com/)

## DIGITAL LITERACY

Explorations with graphics and sounds

[www.edc.org/CCT/dig\\_lit/web/index.html](http://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](http://coweb.cc.gatech.edu/mediaComp-plan)

## ONLINE MATH APPLICATIONS: MUSIC

[library.thinkquest.org/4116/Music/music.htm](http://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/](http://www.artsedge.kennedy-center.org/perfectpitch/)

## THE PERCEPTION DECEPTION

[www.cs4fn.org/illusions/](http://www.cs4fn.org/illusions/)

# COMPUTATIONAL THINKING IN LIFE SCIENCES

## BIOLOGY LABS ONLINE

[nemo.sciencecourseware.org/BLOL/](http://nemo.sciencecourseware.org/BLOL/)

## CONCORD CONSORTIUM

[www.concord.org/resources/browse/172/](http://www.concord.org/resources/browse/172/)

## DISCOVERY CHANNEL INTERACTIVES

### Ice Map, Earth Live and more

[dsc.discovery.com/games/games-tab-04.html](http://dsc.discovery.com/games/games-tab-04.html)

## ONLINE MATH APPLICATIONS: SCIENCE

[library.thinkquest.org/4116/Science/science.htm](http://library.thinkquest.org/4116/Science/science.htm)

## PHASE CONTRAST MICROSCOPE SIMULATION

[nobelprize.org/educational\\_games/physics/imaginglife/index.html](http://nobelprize.org/educational_games/physics/imaginglife/index.html)

## PhET INTERACTIVE SIMULATIONS

### A wide variety of science simulations

[phet.colorado.edu/index.php](http://phet.colorado.edu/index.php)

## SCIENCE ANIMATIONS, MOVIES & INTERACTIVE TUTORIALS

[nhscience.lonestar.edu/biol/animatio.htm](http://nhscience.lonestar.edu/biol/animatio.htm)

## SMITHSONIAN MUSEUM OF NATURAL HISTORY

[www.mnh.si.edu/education/classroom\\_resources/studentactivities/index.html](http://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](http://msdn.microsoft.com/en-us/beginner/default.aspx)

## CENTER FOR COMPUTATIONAL THINKING

### Sponsored by Microsoft® Research

[www.cs.cmu.edu/~CompThink/](http://www.cs.cmu.edu/~CompThink/)

## COMPUTATIONAL THINKING

### Jeannette M. Wing, CMU

[www.cs.cmu.edu/afs/cs/usr/wing/www/publications/Wing06.pdf](http://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](http://iae-pedia.org/Computational_Thinking)

## COMPUTATIONAL THINKING PATTERNS

### See the possibility of computational representation in situations

[scalablegamedesign.cs.colorado.edu/wiki/Computational\\_thinking](http://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](http://cs.gmu.edu/cne/pjd/GP/gp_overview.html)