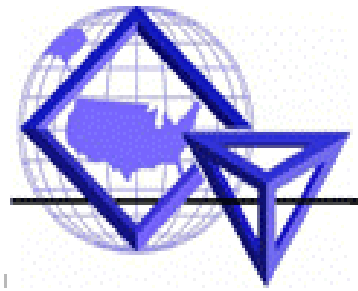


Modeling as an Interactive Learning Environment

Beyond PowerPointlessness

David Joiner
The Shodor Education Foundation, Inc.
Paul Gray
University of Northern Iowa

Outline

- How has computing changed the landscape of science education?
- Have Shodor and NCSI been effective landscapers?
- Incorporating computing into education
- Parallel computing in computational (science education)
- Parallel computing in (computational science) education

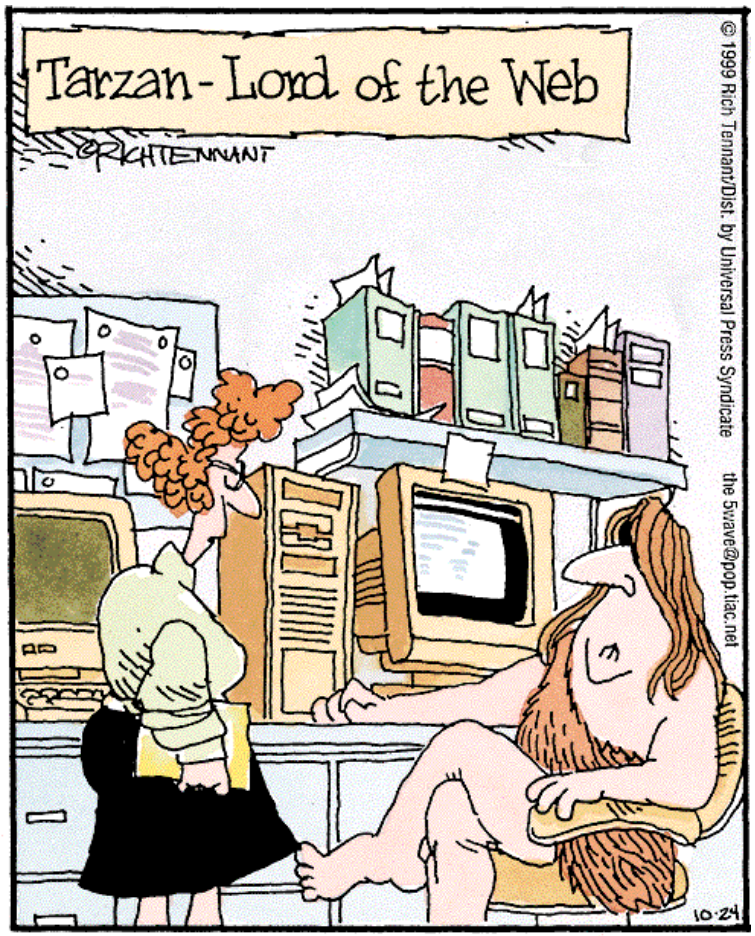
What is Shodor?

- Nonprofit education and research corporation dedicated to the reform and improvement of math and science education at all levels
  - Computational technology
  - Communication technology
  - Modeling technology
  - Scientific Visualization
  - Numerical methods and simulations integrated with curriculum

What is NCSI?

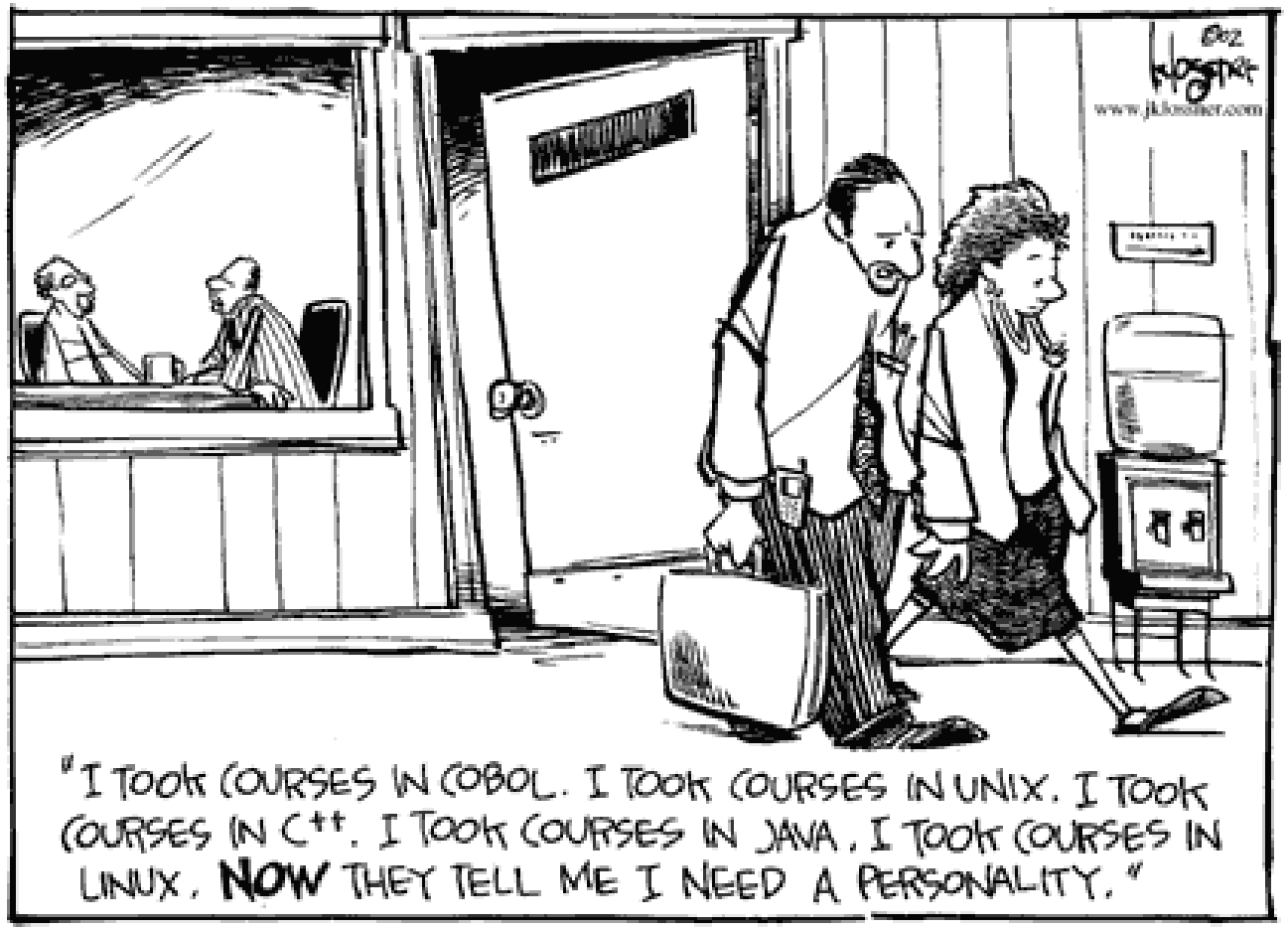
- Faculty and teacher training outreach activity of Shodor and its partners, revitalizing education, integrating technology and curriculum, through hands-on exploration of:
  - Computational science
  - Numerical models
  - Data visualization tools
- Funded in part by National Science Foundation, Division of Undergraduate Education, NCSI offers:
  - In-person workshops
  - Web-based workshops
  - Seminars
  - Other support activities

New Careers...

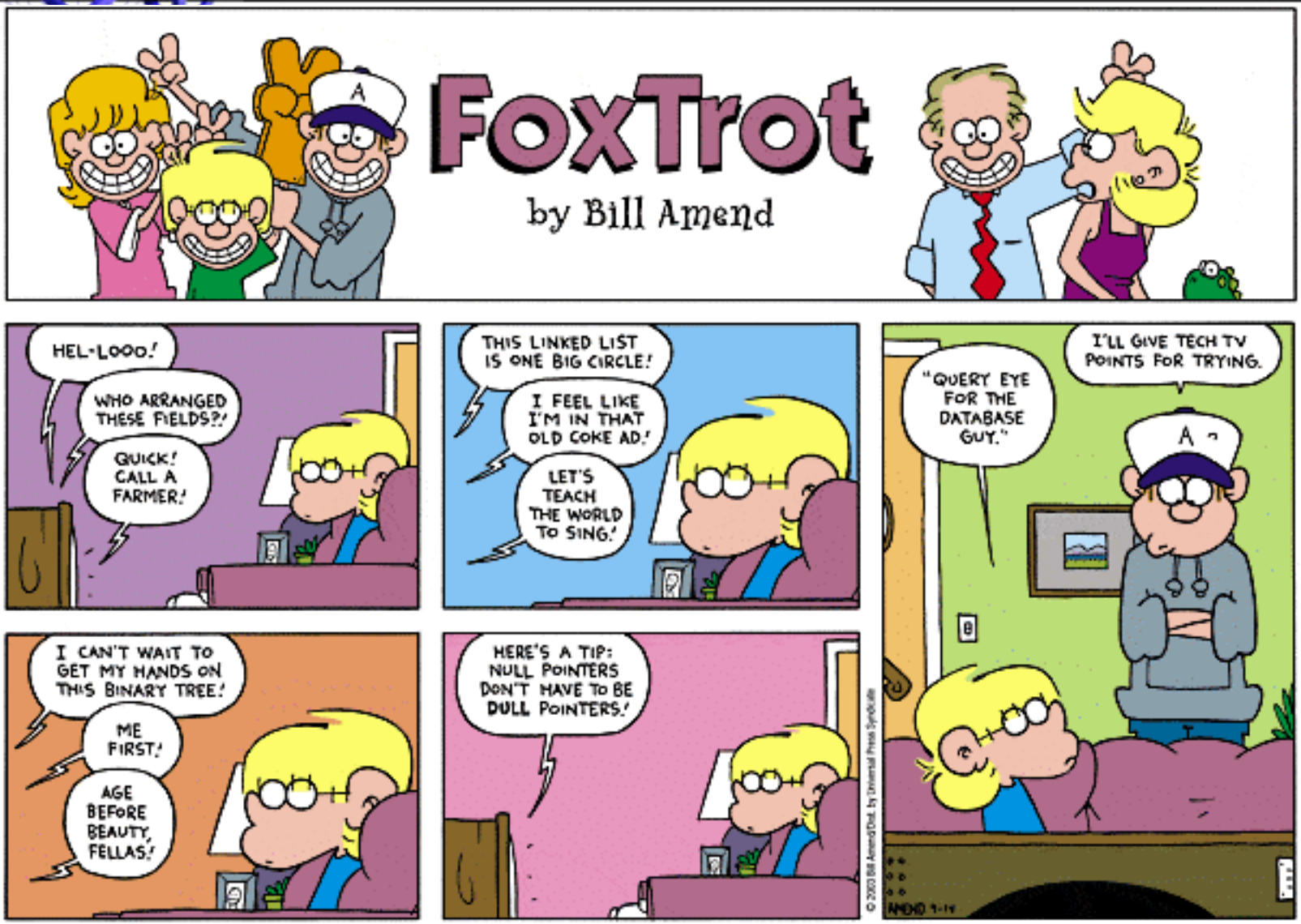


"... and then one day it hit. Tarzan, Lord of Jungle – where future in that?"

...Require More Than Just Training



Keeping Things Fresh



Information Overload

Embedded Technologies

Inevitability of Change

6 [2] On this mountain the LORD of hosts
will provide for all peoples A feast of
rich food and choice wines, juicy, rich
food and pure, choice wines.
7 On this mountain he will destroy the veil
that veils all peoples, The web that is
woven over all nations;

Prophetic Vision

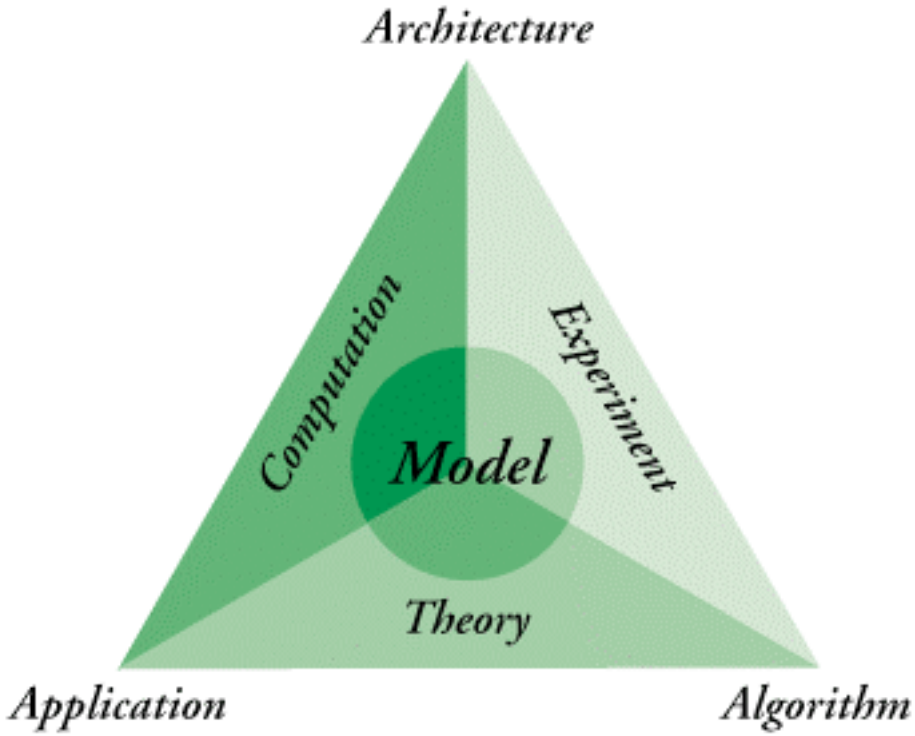
18

... For Windows™ on high will be opened and the foundations of the earth will shake.

19

The earth will burst asunder, the earth will be shaken apart, the earth will be convulsed.

Modeling in Education

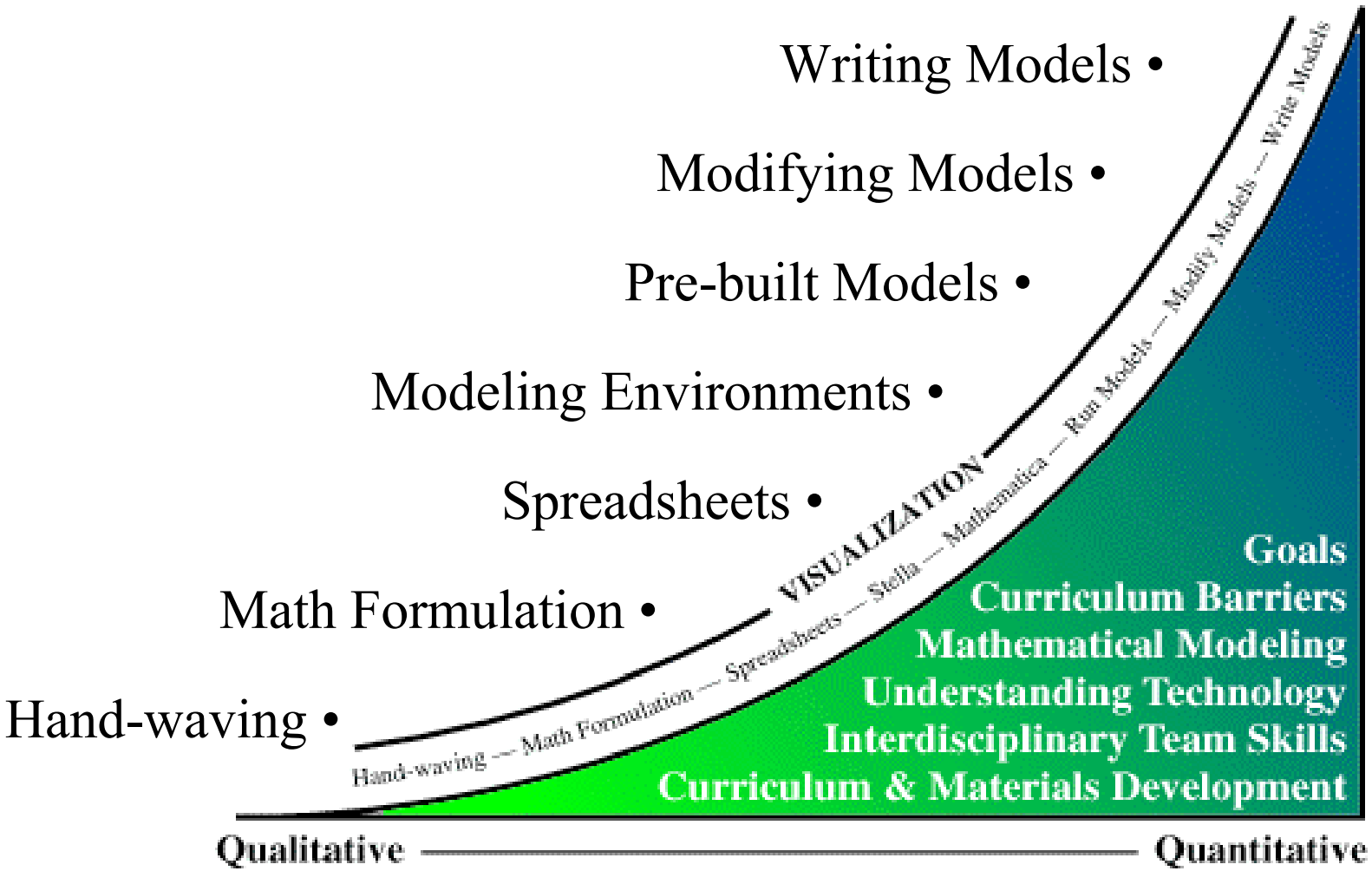


Modern science and mathematics are more properly concerned with pattern recognition and characterization than with mere symbol manipulation.

Types Of Models

- Mental Models
- Physical Models
- Animal Models
- Agent Models
- Data Models
- Mathematical Models
- Numerical Models

(Computational Science) Education



Computational (Science Education)

- Observations
  - accurately recorded
  - honestly reported
  - assumptions
  - biases
- Conjectures
  - what if?
  - consistent vs. conclusive?
- Collaborations
  - peers
  - mentors
  - experts
- Choosing the right
  - tools
  - techniques
  - technologies
- Facilitate hypothesis BUILDING at the right time
- Experiments: Learn-by-doing numerical, visual investigations
- Differences between Observations and Conclusions

Is It Working?

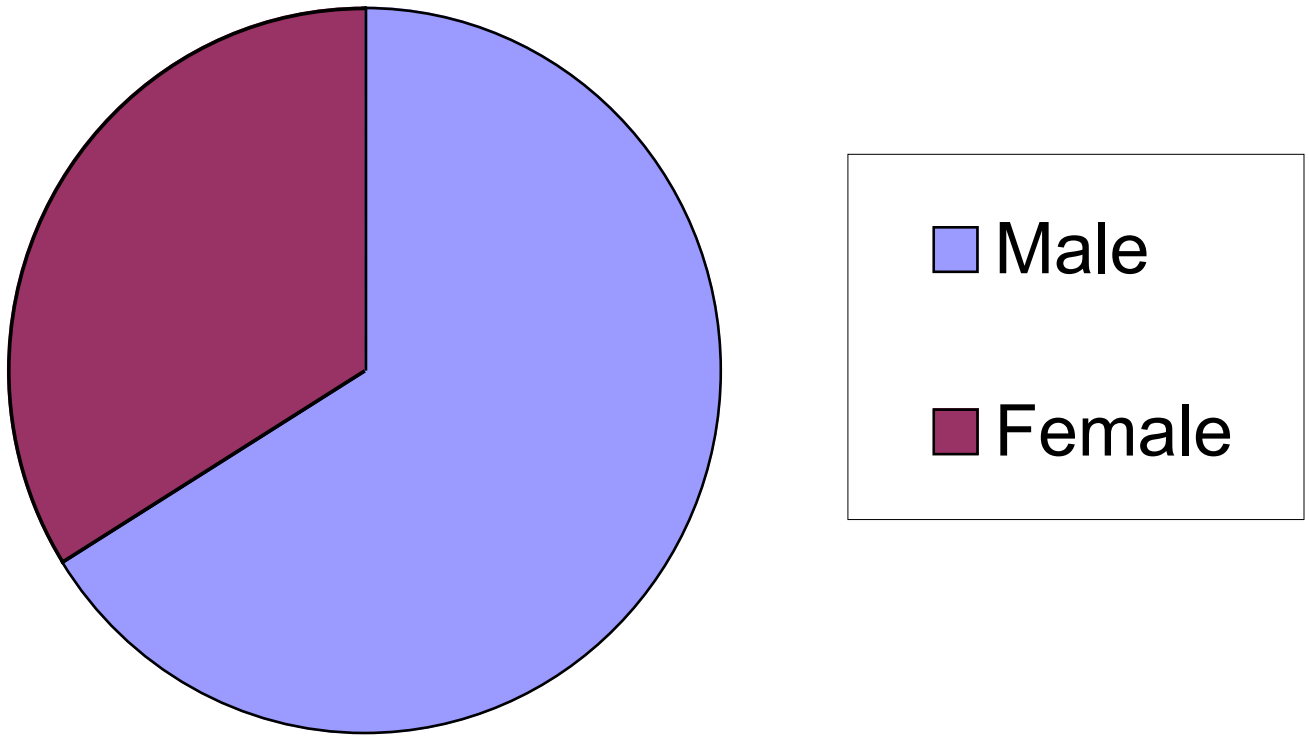
- NCSI Summer 2002
  - 85 faculty members
  - 6 introductoy faculty workshops
- NCSI Summer 2003
  - 250+ faculty members
  - 150+ different institutions
  - 15 faculty workshops
    - Introductory
    - Intermediate
    - Chemistry
    - Parallel computing
    - Teacher training

Is It Working?

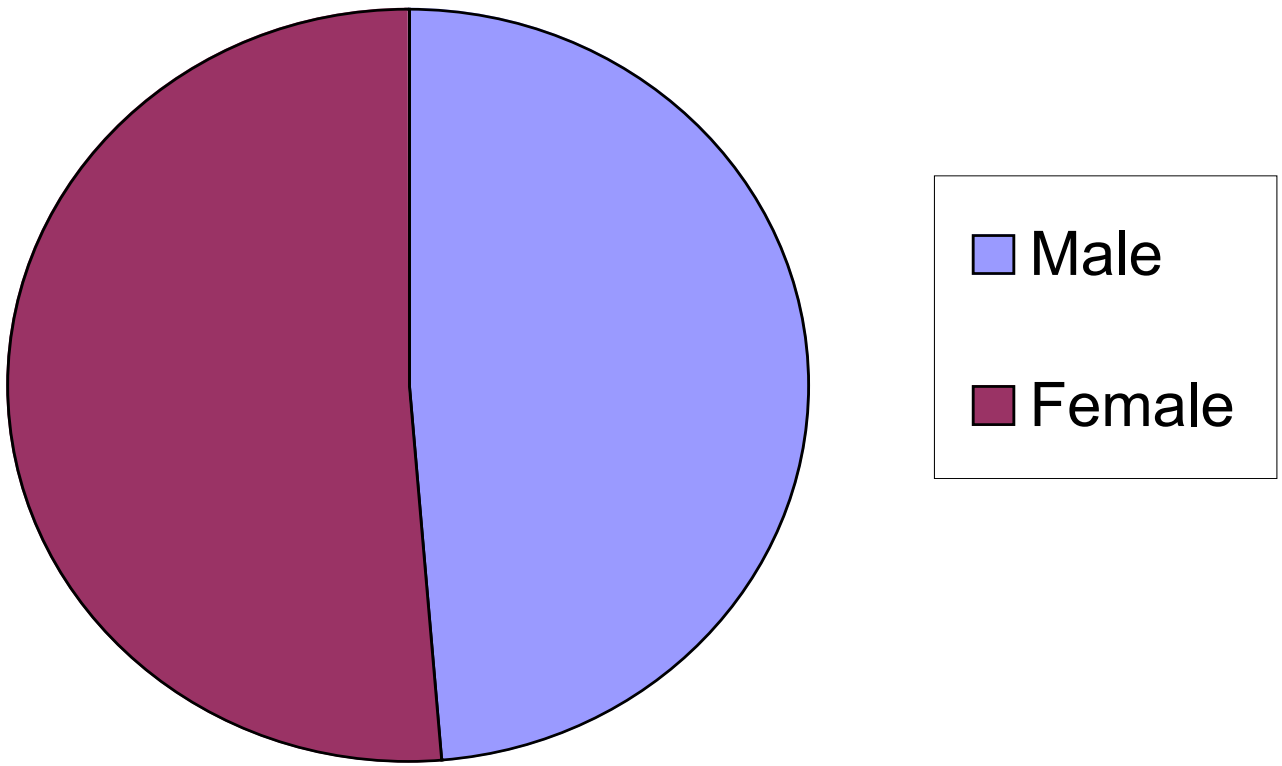
- NCSI 2003
  - 38% minority representation
    - 20% Black-African American
    - 4% Hispanic
    - 14% Asian
  - 37% Female

A New Generation of Professionals

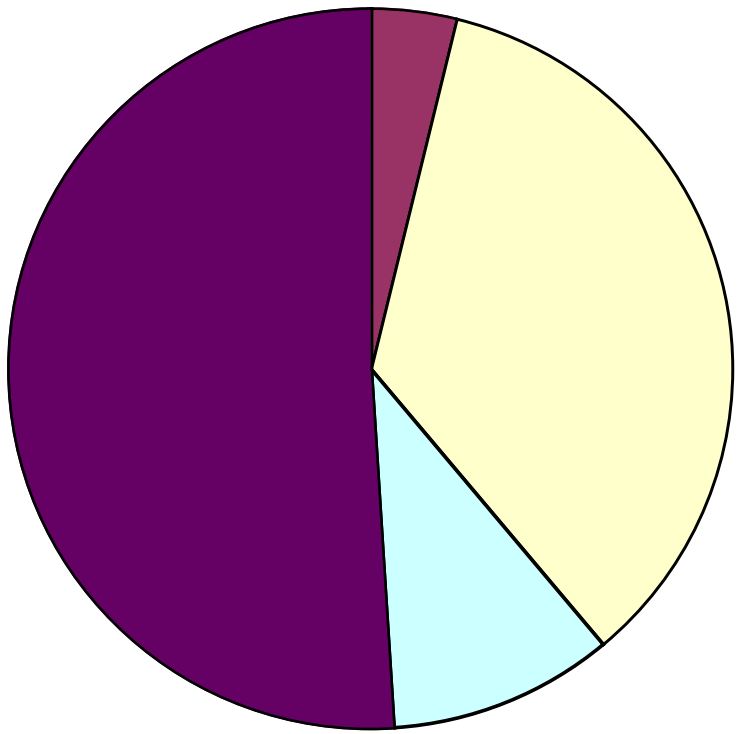
Students - 2001



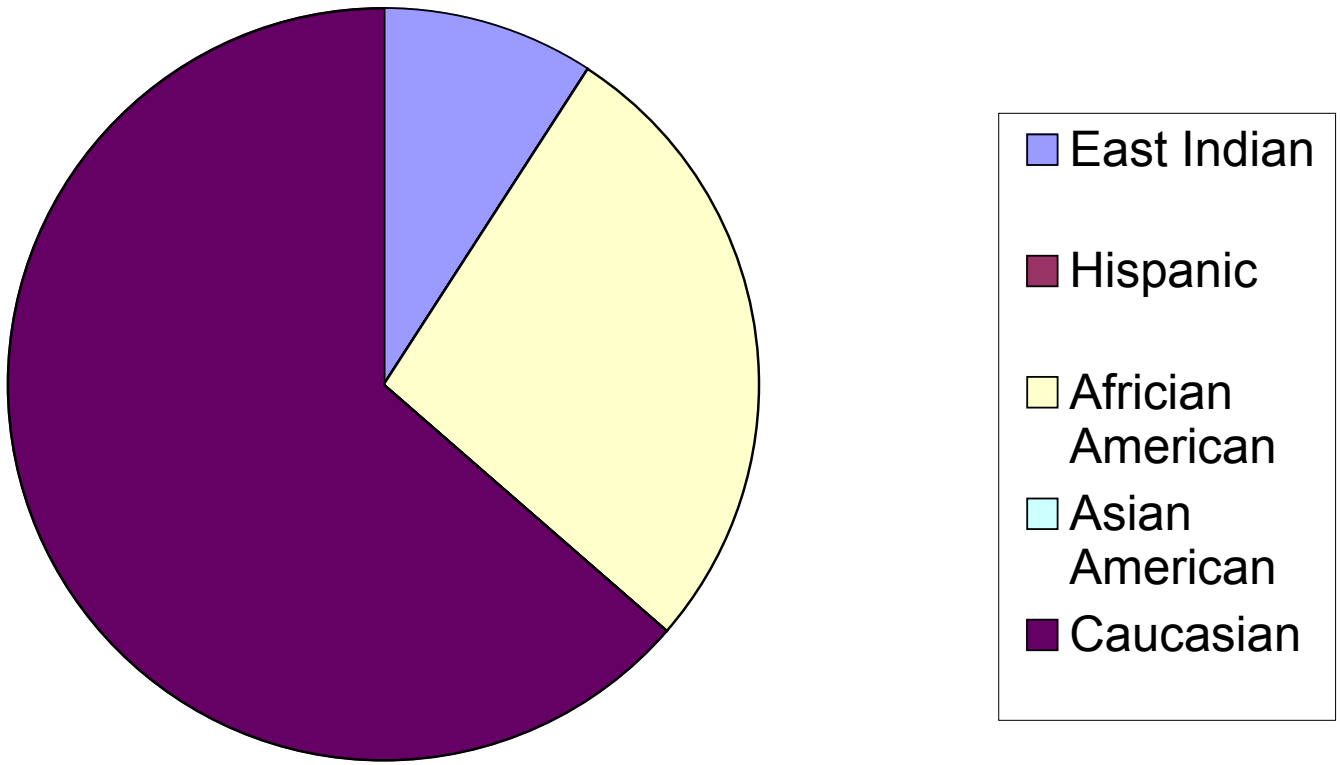
Interns - 2001



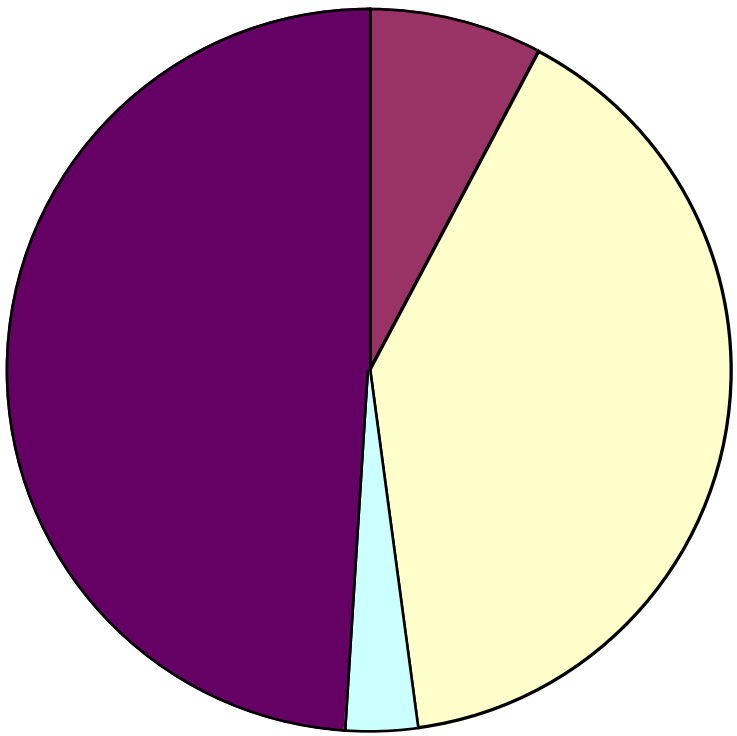
Students - 2001



Interns - 2001



Durham



East Indian

Hispanic

Africian American

Asian American

Caucasian

Is It Working?

- Computational science programs at UNI and across the country
  - The UNI Computational Science “Outreach Program” and new Bioinformatics major
    - Training of undergraduate students for Higher Ed.
  - Wofford College
  - Oregon State
  - NCSA CSE Group
  - Krell Institute

Example 1: A Forest Fire

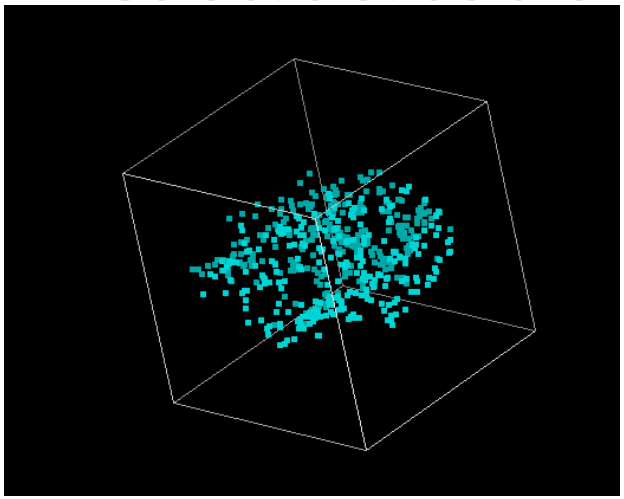
- Web applet
  - Freely available
  - Simple Fire - 700 downloads per month
  - (Middle school math materials see ~35000 users per month)
  - http://www.shodor.org/interactivate/activities/fire1/

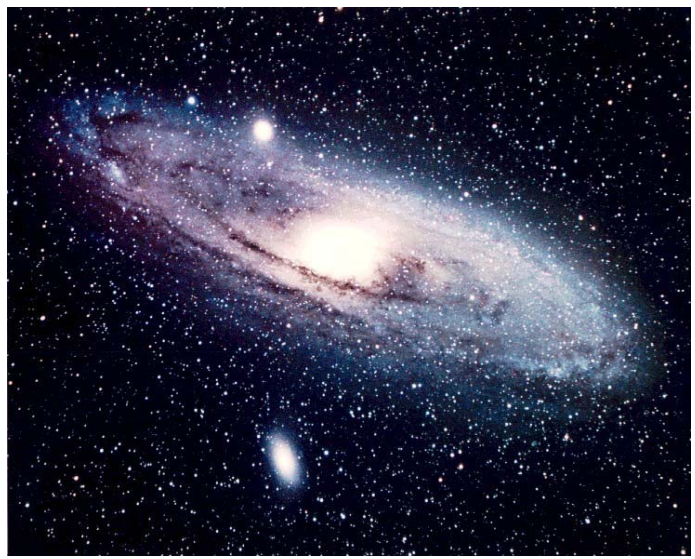
Example 2: Mandelbrot Set

- $z = z^*z+c$
- Rules for addition, multiplication found in Mandelbrot set
- http://www.shodor.org/master/fractal/software/

Example 3: GalaxSee

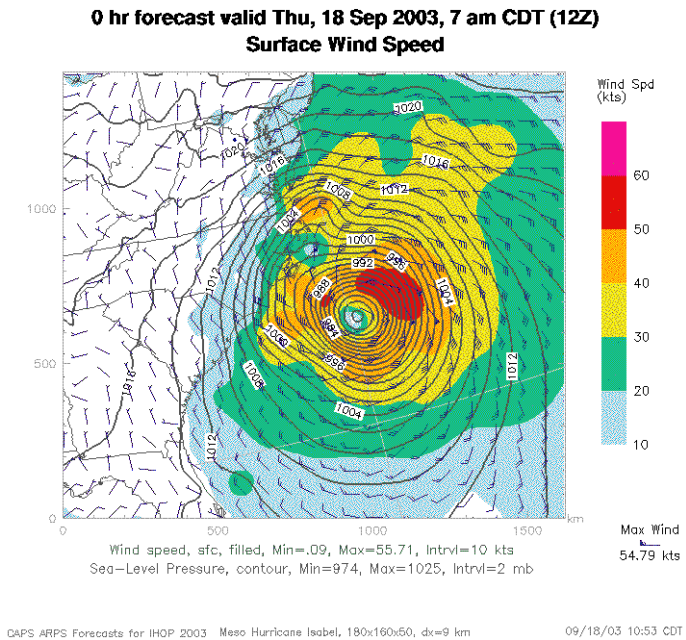
- Windows/Mac/Java/Unix versions
- http://www.shodor.org/master/galaxsee
- N-Body problem
- Orbits
- Galactic structure

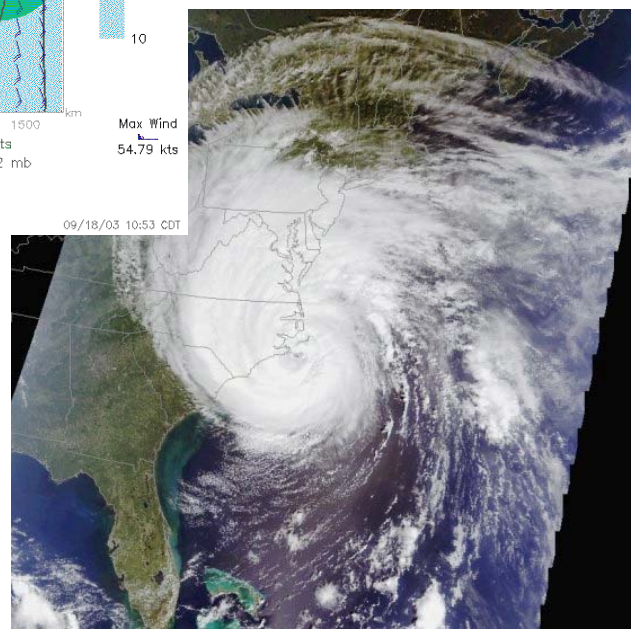




Why Parallel in Education?

- Increasing power needed to treat non-linear problems realistically
- OSCER - Boomer (Top 500 #134)
- climateprediction.net
- Earth Simulator (Top 500 #1)





Why Parallel in Education?

- Computational (Science Education)
  - GalaxSee
    - 100s of bodies
      - angular momentum
      - 100s of MFlops to view in real time
    - 1000s of bodies
      - needed for “fluid” appearance
      - spiral structure NOT due to initial random distribution of matter
      - 10000s of MFlops to view in real time
    - 1000000s of bodies
      - complex physics (collisions, dark matter, gas and dust)
      - weeks, months on world’s fastest machines

Why Parallel in Education?

- Computational (Science Education)
  - GalaxSee
    - High communication requirements.
    - Advanced algorithms, collective communication needed for optimization
    - For test cluster (4 iBooks, YDL, 10Mbs hub) 500 body model slower on 4 nodes than on 1.
    - Better efficiency at larger model sizes, but take longer to run.

Why Parallel in Education?

- (Computational Science) Education
  - Computational Science for Computer Science
    - Natural extension to core CS topics relating to:
      - Schedulers
      - Memory addressing
      - Semaphores and Mutexes
      - Algorithmic Complexity
      - Numerical Analysis
      - Computer Architecture
      - Computer Organization
      - System Administration
      - ...

How can parallel computing be used in education?

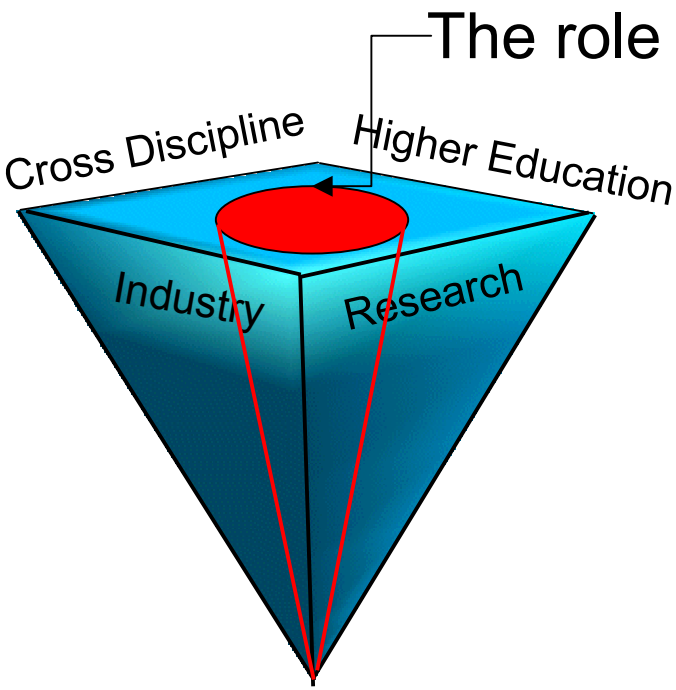
- Curricular Standards (undergraduate)
  - IEEE/ACM Computing Curricula 2001, for Computer Science
    - AL.11 Parallel Algorithms (CS 314)
    - AR.9 Parallel Architectures (CS 321)
    - CN.4 High Performance Computing (CS 222w)
    - Net-Centric Computing (CS 230)
    - SE.12 Specialized Systems Development (elective)

How can parallel computing be used in education?

- Specific ways of getting HPC into the curriculum:
  - You need some HPC resources.
    - Build your own, from scratch.
    - OSCAR (http://oscar.sourceforge.net)
    - NPACI Rocks (http://rocks.npaci.edu/Rocks/)
    - Bootable Cluster CD (http://bccd.cs.uni.edu)
    - See Henry for OSCER access
    - allocations@ncsa.uiuc.edu

How can parallel computing be used in education?

- HPC Curricular Emphasis doesn't have to be isolated.



What Resources are Available?

- Faculty training
  - OU Symposium
  - NCSI Workshops
    - Week-long summer workshops
    - Assorted workshops w/ SC, Sigma Xi, CCSC, others
    - http://www.computationalscience.org
- Materials
  - Computational Science Education Reference Desk
    - http://www.shodor.org/cserd
  - Bootable Cluster CD Project
    - http://bccd.cs.uni.edu