Modeling as an Interactive Learning Environment

Beyond PowerPointlessness

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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
“... and then one day it hit. Tarzan, Lord of Jungle – where future in that?”
...Require More Than Just Training

“I took courses in COBOL, I took courses in UNIX, I took courses in C++. I took courses in JAVA, I took courses in LINUX, **Now** they tell me I need a personality.”
Keeping Things Fresh

FoxTrot
by Bill Amend

HEL-LOOO!

WHO ARRANGED THESE FIELDS?!

QUICK! CALL A FARMER!

THIS LINKED LIST IS ONE BIG CIRCLE!

I FEEL LIKE I'M IN THAT OLD GONE AD!

LET'S TEACH THE WORLD TO SING!

I CAN'T WAIT TO GET MY HANDS ON THIS BINARY TREE!

ME FIRST!

AGE BEFORE BEAUTY, FELLA!

HERE'S A TIP: NULL POINTERS DON'T HAVE TO BE DULL POINTERS!

“QUERY EYE FOR THE DATABASE GUY.”

I'LL GIVE TECH TV POINTS FOR TRYING.
Information Overload

Negotiating traffic on the road to the information superhighway.
Embedded Technologies

“Now you can surf and turf.”
6 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;
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.
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

- Writing Models
- Modifying Models
- Pre-built Models
- Modeling Environments
- Spreadsheets
- Math Formulation
- Hand-waving

Goals
- Curriculum Barriers
- Understanding Technology
- Interdisciplinary Team Skills
- Curriculum & Materials Development

Visualisation
- Hand-waving
- Math Formulation
- Spreadsheets
- Stella
- Mathematica
- Run Models
- Modify Models
- Write Models

Qualitative

Quantitative
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 introductory 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
Interns - 2001

- Caucasian
- African American
- Asian American
- Hispanic
- East Indian
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/](http://www.shodor.org/interactivate/activities/fire1/)
Example 2: Mandelbrot Set

- \( z = z^2 + c \)
- Rules for addition, multiplication found in Mandelbrot set
Example 3: GalaxSee

- Windows/Mac/Java/Unix versions
- [http://www.shodor.org/master/galaxsee](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.

The role of NCSI!

Cross Discipline  Higher Education  Research

Industry

Undergraduate CS Education
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](http://www.computationalscience.org)

- **Materials**
  - Computational Science Education Reference Desk
    - [http://www.shodor.org/cserd](http://www.shodor.org/cserd)
  - Bootable Cluster CD Project
    - [http://bccd.cs.uni.edu](http://bccd.cs.uni.edu)