



Creating a Dialog Between Science and Computer Science

SECANT Workshop

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Why We Need a Dialogue

Scientists and engineers. Not learning computer science.
Computer scientists. Not learning science or engineering.

Result. Both groups are getting shortchanged.

"All students interested in science and engineering should develop a common technical basis in math, science, and computing before moving into discipline-specific studies."

Beginning a Dialog

Q. What do **scientists** care about?

- Simulation.
- Data analysis.
- Scientific method.
- Transferable programming skills (C, Perl, Matlab, Fortran, ...)



Q. What do **computer scientists** care about?

- Modularity.
- Data abstraction.
- Transferable programming skills (C++, Python, Javascript, ML, ...)

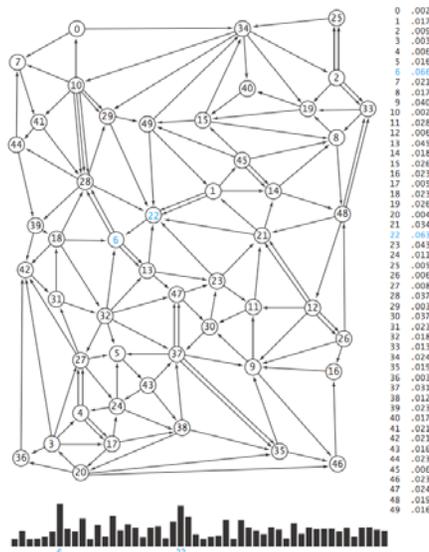
SECANT Workshop

- Introduction
- **Our approach**
- Collaborations
- Results

Our Interdisciplinary Approach

Our interdisciplinary approach.

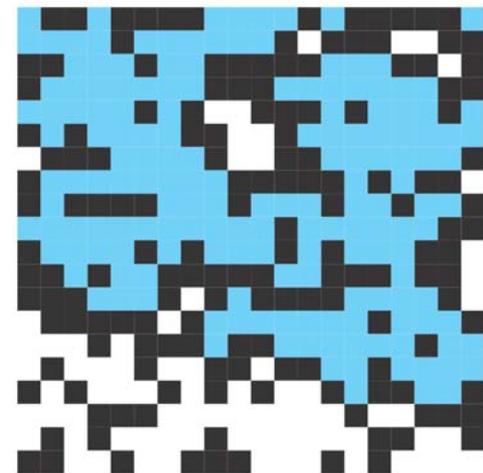
- Scientific method.
- **Infuse curriculum with scientific applications.**
- Leverage typical high-school background in math/science.
- Modern programming model (control flow, I/O, data abstraction).



PageRank

```
A A C A G T T A C C
T A - A G G T - C A
```

Sequence Alignment



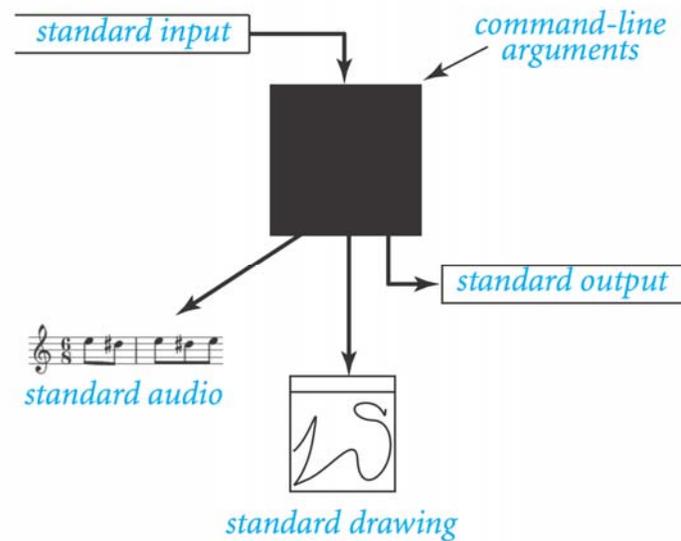
Percolation

Input and Output

Input and output. Read and write numbers and text.

Drawing. Draw figures and animations.

Audio. Create and manipulate sound.



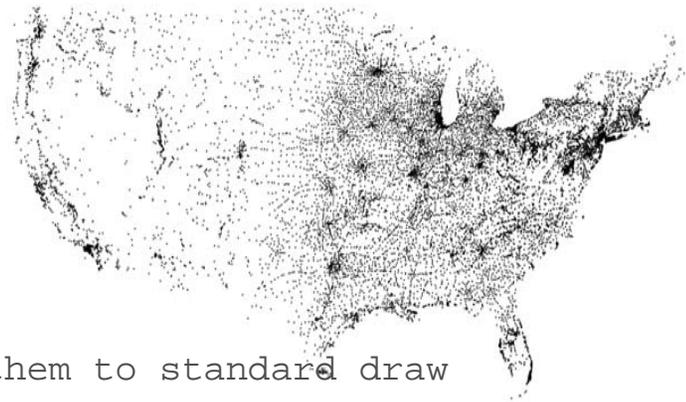
Input and Output

Input and output. Read and write numbers and text.

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```
while (!StdIn.isEmpty()) {  
    double x = StdIn.readDouble();  
    double y = StdIn.readDouble();  
    StdDraw.point(x, y);  
}
```



read points from standard input and plot them to standard draw

Lessons. Provide easy-to-use I/O libraries; use real data.

Input and Output

Input and output. Read and write numbers and text.

Drawing. Draw figures and animations.

Audio. Create and manipulate sound.

```
double seconds = 2.0;
int N = seconds * StdAudio.SAMPLE_RATE;
for (int i = 0; i <= N; i++) {
    double sample = Math.sin(2 * Math.PI * i * 440 / StdAudio.SAMPLE_RATE);
    StdAudio.play(sample);
}
```

concert A

create a sound wave and play it on standard audio



concert A



concert A with harmonics

N-Body Simulation

N-Body simulation. Simulate the motion of N particles, mutually affected by gravitational forces.

$$F = \frac{G m_1 m_2}{r^2} \quad + \quad F = m a \quad + \quad \text{leapfrog method}$$

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

Molecular Dynamics

Event-drive simulation. Simulate the motion of N particles subject to laws of elastic collision.

$$J = \frac{2m_1m_2(\Delta v \cdot \Delta r)}{(\sigma_1 + \sigma_2)(m_1 + m_2)} \quad + \quad F = ma \quad + \quad \text{event-based simulation}$$

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Integrated Science

Integrated science. Revolutionary intro science curriculum designed for students considering a career in the sciences.

“Any budding researcher needs a foundation in several fields to be able to work on the most important problems confronting scientists today.” – David Botstein

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Curriculum. Biology + chemistry + physics + **computer science.**



Avogadro's Number

Avogadro's number. Analyze video microscopy data; track the motion of particles undergoing Brownian motion; fit the data to Einstein's model; and estimate Avogadro's number.

$$D = \frac{k T}{6 \pi \eta \rho} + \text{depth first search} = 6.022 \times 10^{23}$$

QuickTime™ and a decompressor are needed to see this picture.

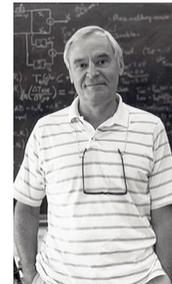
Engineering

Engineering departments. CHE, CEE, CS, ELE, MAE, ORFE.

Then. (1999–2004) Most engineers took one of 4 different intro courses, offered in 4 different departments.

Course redesign. (Fall 2004)

“If you create a good course, people will take it.” — David Wilkinson



Now. (2005–present) 95% of engineers take our intro course.

↖
ε other courses remain

Purple America

Election 2004 Results

Robert J. Vanderbei

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The changing colors of America (1960-2004).
Click animated gif for full-sized version...

2004 Presidential Election
Purple America

Click [here](#) for Election 2006 map.
Click [here](#) for Election 2005 maps.
Click [here](#) for Election 2000 map.

To license very high resolution versions of these maps, contact the author.

Using County-by-County election return data from [USA Today](#) together with County boundary data from the US Census' [Tiger database](#) we produced the following graphic depicting the results. Of course, blue is for the democrats, red is for the republicans, and green is for all other. Each county's color is a mix of these three color components in proportion to the results for that county.

Counties shown in black represent either missing election data or a mismatch between the US Census data and the USA Today data. For example, the New England states' election return data is given for each municipality and/or district rather than for each county. Hence, it couldn't be easily matched with the county boundaries.

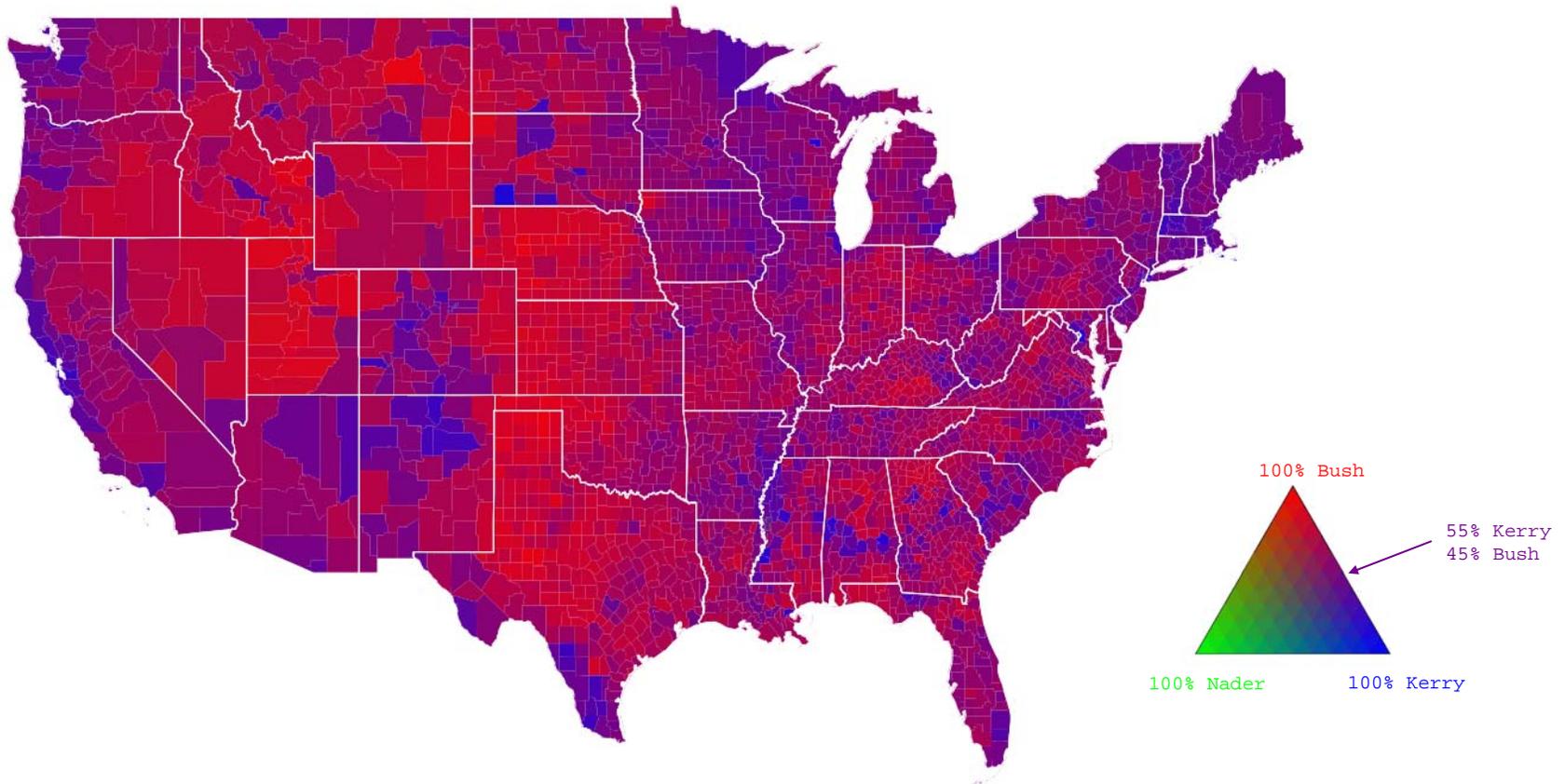
Click anywhere on the map for a larger version.



Bob Vanderbei
Chair, Operations Research
and Financial Engineering

Purple America

Purple America. Download map data from TIGER; screen scrape election results from www.uselectionatlas.org ; plot visualization.

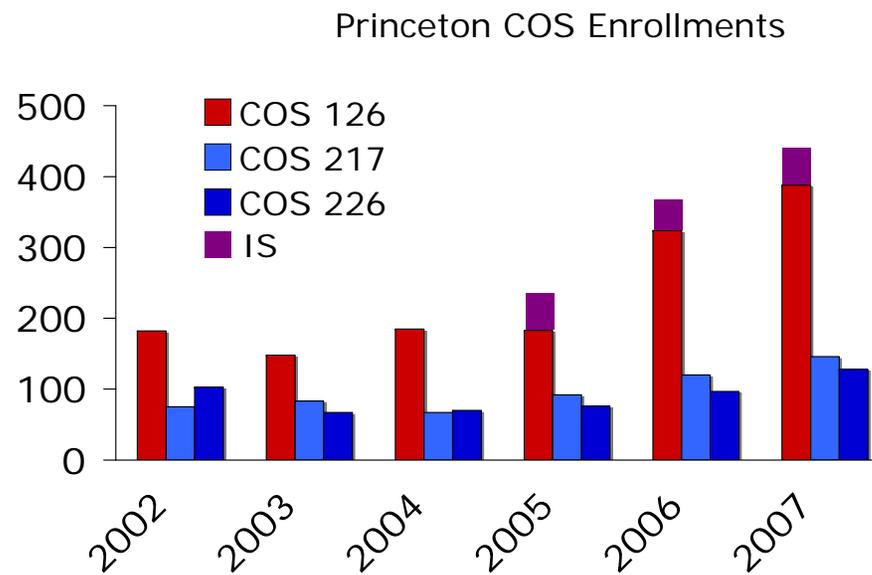


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Success Story at Princeton

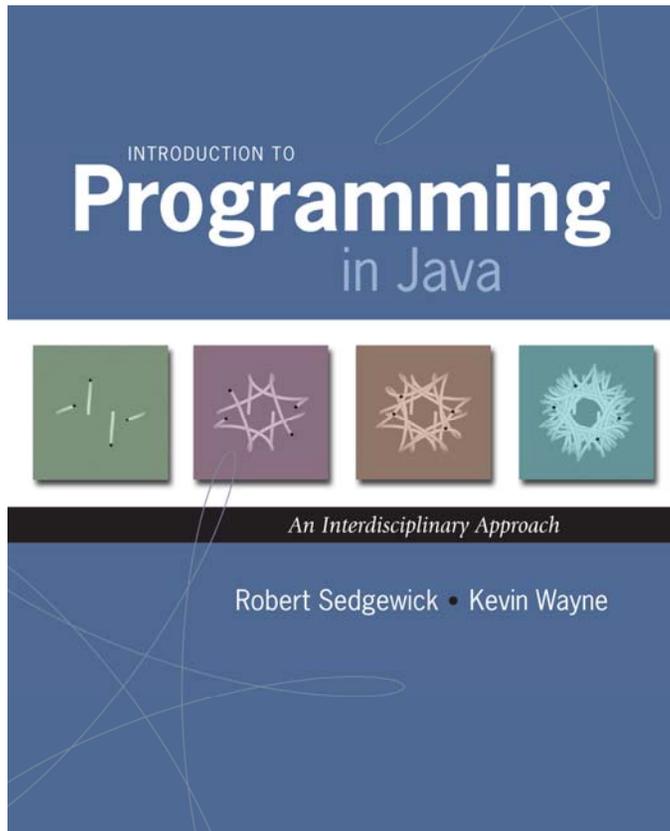
Our enrollments. 40% of all Princeton students (and increasing).



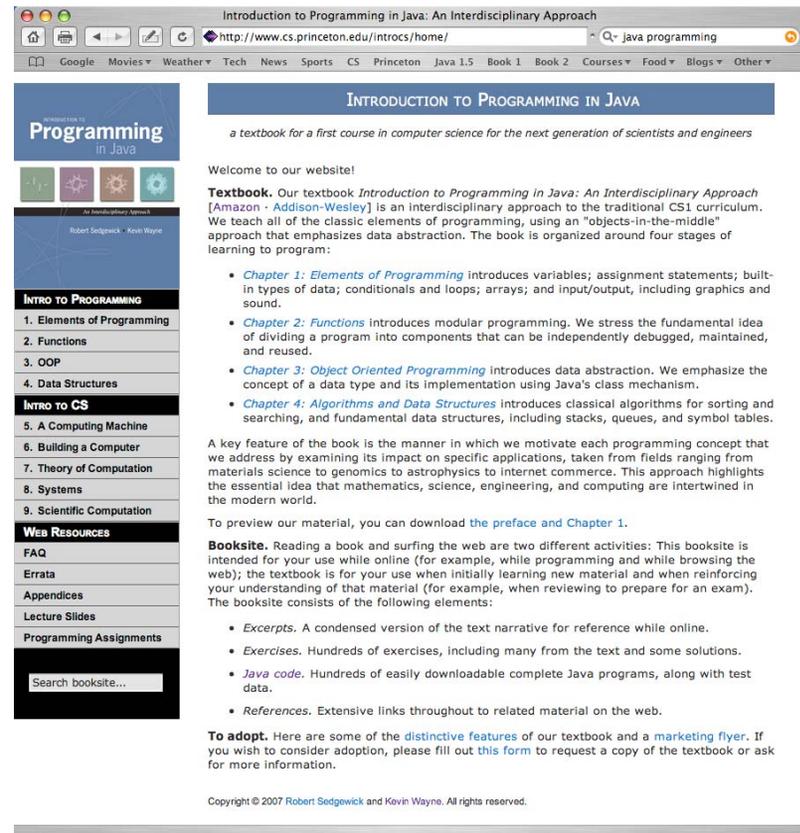
Q. How to replicate at other institutions?

A New Textbook

“ A textbook for a first course in computer science for the next generation of scientists and engineers. ”



Addison-Wesley, 2007



<http://www.cs.princeton.edu/IntroProgramming>