Improving Undergraduate Computing Education
NSF Site Visit, December 5, 2008

Why we do what we do, and what we do
- Why we think new curricula can make a difference:
  - The story of Georgia Tech’s CS1’s
    - Media Computation
    - Engineering computing with MATLAB
    - Robotics
    - Experiences elsewhere
- Supporting use of innovative curricula in Undergraduate computing across Georgia
  - Workshops
  - Support
  - Evaluation

Fall 1999: Georgia Tech
- As of Fall 1999:
  All students at Georgia Tech must take a course in computer science.
- Key Point: Only one course met the requirement:
  CS1321 Introduction to Computing
    - Shackelford’s pseudocode approach in 1999
    - Later Scheme: How to Design Programs (MIT Press)

Contextualized Computing Education
- What’s going on?
  - Research results: Computing is “tedious, boring, irrelevant”
- Since Spring 2003, Georgia Tech teaches three introductory CS courses.
  - Based on Margolis and Fisher’s “alternative paths”
- Each course introduces computing using a context (examples, homework assignments, lecture discussion) relevant to majors.
  - Make computing relevant by teaching it in terms of what computers are good for (from the students’ perspective).

One-class CS1: Pass (A, B, or C) vs. WDF (Withdrawal, D or F)

| Success Rates in CS1 from Fall 1999 to Spring 2002 (Overall 78%) |
|-------------------|----------------|-----------|
| Architecture      | 46.7%          |
| Biology           | 64.4%          |
| Economics         | 53.5%          |
| History           | 46.5%          |
| Management        | 48.5%          |
| Public Policy     | 47.9%          |

Our Three CS1’s Today
- CS1301/1321 Introduction to Computing
  Traditional CS1 for our CS majors and Science majors (math, physics, psychology, etc.). Uses robots.
- CS1371 Computing for Engineers
  CS1 for Engineers. Same topics as CS1301, but using MATLAB with Engineering problems in homework and examples.
- CS1315 Introduction to Media Computation
  ~300 students/semester. 51% female.
Media Computation: Teaching in a Relevant Context

- Presenting CS topics with media projects and examples
  - Iteration as creating negative and grayscale images
  - Indexing in a range as removing red eye
  - Algorithms for blending both images and sounds
  - Linked lists as song fragments woven to make music
  - Information encodings as sound visualizations

A Contextualized CS2: Media Computation Data Structures

- With students passing CS1, call for CS2 (Data Structures) in a Media Computation context.
- About 10% of MediaComp CS1 students go on to CS2.
  - (About 10% of those get a computing minor or major.)
- 90% average success rate over last three years (2005-2008).
- Over 30% female.

Introducing Computing in an Engineering Context

- Developed in collaboration with Civil, Mechanical, and Aerospace Engineering.
- Uses Engineering problems and MATLAB
- Covers traditional CS1 topics
- Among our 3 CS1’s, these are the first students to program outside of class.

Results: CS1 “Media Computation”

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall 03</th>
<th>Fall 04</th>
<th>Fall 05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>46.7%</td>
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Results: CS1 for Engineering

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Side Trip: How about CS?

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**Comparing Spring 2004**

<table>
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<tr>
<th>Media Comp</th>
<th>Engineering</th>
<th>CS</th>
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<tbody>
<tr>
<td>89.87</td>
<td>75.27</td>
<td>68.26</td>
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**A Context for CS1 for CS majors: Robotics**

- Microsoft Research has funded the Institute for Personal Robotics in Education
  - Tucker Balch, Deepak Kumar, Doug Blank
  - Joint between Bryn Mawr and Georgia Tech
  - [http://www.roboteducation.org](http://www.roboteducation.org)
- Goal is to develop a CS1 with robotics as the context.
  - Includes a camera and media computation functions

**Results at Gainesville College**

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<tr>
<th>Semester</th>
<th>Autumn 2003</th>
<th>Autumn 2004</th>
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<tbody>
<tr>
<td>Media</td>
<td>86.0%</td>
<td>80.8%</td>
</tr>
<tr>
<td>Average</td>
<td>70.3%</td>
<td>65.9%</td>
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</table>

**Results at U. Illinois-Chicago**

Table 3: Enrollments for CS 1.

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<thead>
<tr>
<th>Fall 2002</th>
<th>Fall 2003</th>
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<tbody>
<tr>
<td>59</td>
<td>71.4%</td>
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<tr>
<td>51</td>
<td>76.1%</td>
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**What “Georgia Computes!” does**

- **Workshops for Faculty**
  - Providing experience in media, MATLAB, and robotics.
  - How to run a summer camp.
- **Support for Faculty**
  - Q&A, resources both curricular and evaluation
- **Tracking adoption and adoption issues.**

**Faculty Workshops**

- "Innovative First Courses Curricula"
  - Offered in Feb and June 2007 in Atlanta, July 2007 at Georgia Southern, May 2008 at Georgia Tech, July 2008 at UMass-Amherst (for CAITE).
  - MediaComp CS1 (Java+Python), MediaComp CS2 Java, Engineering in MATLAB, Robotics in Python
- "Media Computation"
  - Offered in June 2007 and May 2008 at Georgia Tech. (In Boston July 2008 for CAITE teachers.)
  - MediaComp CS1 (Java+Python), MediaComp CS2 Java
- "How to run a summer camp"
  - Offered in December (on logistics) and May (on curriculum) 2007 and 2008.
Examples of Teacher Work

Media Computation adoption at Columbus

- Trial at Columbus State University
- Fall 2007, 3 sections of CS1 for Majors: Media Computation Java vs. traditional
  - From Wayne Summers (Dept Chair):
    - We also taught two other CS1 sections without the Media Computation focus (using the Lewis/Loftus book) and are assessing the difference. The Media Computation class had a significantly higher completion and pass rate and appears to have a higher student satisfaction rate. We will be able to better compare the two methods after this semester. Students from both groups are taking the same CS2 class.
- Spring 2008: Same CS2 for all 3 sections.
- Results:
  - No difference on retention rates, midterm exam grades, final exam grades.

Model and Challenges

- Overall model is GT providing curriculum and evaluation resources.
  - Support for adaptation, as well as adoption.
- Challenges:
  - Far fewer faculty attending than hoped.
  - Faculty training in Computing.
  - Social and institutional inertia.
  - Long cycle time.
  - The “maybe next year” effect.
  - Are these the right models?

Next: Disciplinary Commons for Computing Educators (DCCE)

- Newly funded CPATH grant.
- Common themes heard in teacher interviews:
  - Secondary teachers want to know what UG CS is like and want a community.
  - Undergrad faculty want to influence high schools.
- We are going to hold three, year-long disciplinary commons (monthly face-to-face meetings with online support) with both UG faculty and secondary teachers.
  - To share techniques.
  - To develop a shared evaluation project.
  - To address the community and communications issues.

Evaluation Outputs

- By yr 3, 60 University System of Georgia faculty are prepared to teach contextualized computing.
- Gather baseline and results data on female and minority success and retention rates across USG.
Evaluation Outcomes

- Double the share of undergraduate computing seats that women and minorities have in Georgia
- Expand the pipeline of female and minority students applying for and pursuing undergraduate and graduate computing degrees

Evaluation Outcomes

- By yr 3, 60 University System of Georgia faculty are prepared to teach contextualized computing
  - 2007: 26
  - 2008: 14
- 32 of 35 Georgia Institutions offer CS/CIS
- Attendees from 17 of those institutions
- 7—10 institutions indicated that they have or intend to adopt/adapt

What faculty worry about...

- How will we ensure that students learn the same material?
- How will the innovation motivate students to enroll and persist in the major?
- How will the innovation help us maintain quality?
- How will the innovation assure us that students are well-prepared for upper-level courses?
- What’s really the important material, and how will the innovation highlight it? How will this change affect all the stakeholders?
- What is sufficient motivation to change? Could it be the demonstration of improved student performance, deeper understanding of fundamental programming, increased demand for the course, increased diversity in each class, interdisciplinary outreach, etc.?

Remaining Evaluation Items

- Gather baseline and results data on female and minority success and retention rates across USG
- Double the share of undergraduate computing seats that women and minorities have in Georgia
- Expand the pipeline of female and minority students applying for and pursuing undergraduate and graduate computing degrees

- Submitted request for supplemental evaluation funds to gather and analyze data across the 32 institutions with CS/CIS programs