The Teaching of Computing Should be Challenging, Exciting and Hands-on: Then They Will Come

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Duke University

Broadening Participation in Computing Disciplines Conference
Virginia Beach, VA
October 10, 2008

Supported by the National Science Foundation with additional support from International Business Machines, Microsoft and CRAW Distributed Mentor Program.
Outline

• Introduction: Motivation
• Two Projects - Attraction to CS
  – Peer Led Team Learning (PLTL) in CS
    • Non-majors and Intro CS (undergraduate level)
    • Includes Pair Programming and Collaborative Learning
  – Adventures in Alice Programming
    • Outreach to High School and Middle Schools
• Conclusions for Both Programs
Motivation

• Taulbee Survey 2006-07 - CS BS majors decline
  – 50% drop in enrollment since 2001
  – 11.8% female
  – 5.3% hispanic
  – 3.6% african american

• Many other studies show the low number of interest in CS by females and underrepresented minorities
How does one Attract and Retain to a discipline?

• To Attract – introduction must be
  – Challenging, exciting and hands-on

• To Retain – the courses must be
  – Challenging, exciting and hands-on
How do we Introduce and Teach Science?

• Physics – experiments
• Chemistry - experiments
• Biology - experiments
How do we Introduce Computer Science?

- Write a calculator
- Write a banking program
- Etc...
Why Can’t the Introduction of Computer Science be exciting?

• Programming – it’s always been
  – Hands-on
  – Interactive
  – Frustrating!

• What’s missing?
  – Not Getting Exciting Results
    • Easily, right away
  – Not appealing to today’s kids in which media and technology are a part of their life!
Two Projects on Attraction to CS

• Peer Led Team Learning (PLTL) in CS

• Adventures in Alice Programming

• Both are challenging, exciting and hands-on
Peer-Led Team Learning in CS (PLTL in CS)

- Combines components from PLTL and ESP
- Eight Universities – Fall 2005 – Spring 2008
  - Beloit College (WI)
  - Duke University (NC)
  - Georgia Tech (GA)
  - Loyola College (MD)
  - Purdue University (IN)
  - Rutgers University (NJ)
  - University of Wisconsin Madison (WI)
  - University of Wisconsin Milwaukee (WI)

- www.pltlcs.org

Supported by the National Science Foundation collaborative Grants CNS-0420436, 0420343, 0419340, 0420433, 0420358, 0420312, 0420368, 0420337, 0638510 and 0638499 and a donation from Microsoft.
What is PLTL?

• Related to a course
  – Students solve problems in small groups outside of class
  – All students participate
  – Led by trained undergraduate student leaders who facilitate group learning

• Used in Chemistry  www.pltl.org

• Beneficial to both students and student leaders
What is ESP?

• Emerging Scholars Program
  – Used in math and science courses
  – Recruits under-represented groups
  – Works in small groups on challenging problems

• Benefits
  – Earn Higher Grades
  – Increases enthusiasm for math and science

Defining PLTL in CS (also called ESP-PLTL)

- Small groups meet related to a course
  - Not everyone from the course
  - Build friendships to help support you through major
- Active recruiting
- Aim for gender balance
- Undergraduate peer leaders
- Solve challenging problems
PLTL in CS variations among 8 universities

- Some focus on non-majors course
- Some focus on CS 1
- Some focus on both (one year)
- Some have just women, most are mixed
- Some include everyone, most are subset

- All use active recruiting and undergraduate peer leaders
- All use problem solving in small groups outside of main class period
Duke University - “PLTL in CS” version
Emerging Scholars Program (DES)

• One year program – four courses total
  – First semester
    • Main course: Non-majors course: CPS 4 (Alice) (1 credit)
    • Problem Solving Seminar course: CPS 18S (1/2 credit)
  – Second Semester
    • Main Course: CS 1 course: CPS 6 (java)
    • Problem Solving Seminar course: CPS 18S (1/2 credit)
  – Active Recruiting (email to targetted groups, accepted student fairs, invite students in main course)
  – Gender balanced
  – Outside Speaker/Field Trip
  – Undergraduate Peer Leaders in Problem Solving Seminar
CompSci 18S: Problem Solving Seminar

• 2 peer leaders, about 12 students, (1 professor)
• Solve problems in groups of 4
• Either general computer science problems or related to the main course
• Subset of students from main course, those who want the group experience
• Peer leaders trained in workshop, meet weekly
Example of Problem Solving: Be A Robot

- Group of 4 – brain, eyes, 2 hands
- Only brain knows what you are building
- Only eyes can see
- Must work together precisely like a robot
Example of Problem Solving Finding

- Graph of all friends (of everyone in class, at your university)
- Problems
  - Find number of friends of friends of someone
  - Find the center of the graph – person with smallest sum of shortest distances
Other Examples

- Finite State Machines
- Turing Machines
- Random Numbers
- Compression (Huffman coding)
- Sudoku, Jumble
- L-Systems
- Genomics
2 Main Courses: Non-majors (Alice) and CS 1 (Java)

- Workshop format
  - Lecture 10-20 minutes
  - Students program rest of class
  - Students work in pairs ("pair programming")
    - Two people, two laptops, consult a lot
  - Assigned seats and pairs, change every 2-3 weeks
- About 35-50 students
2 Main Courses: Undergraduate role

- About 8-10 undergraduate teaching assistants
- Roles:
  - Attend the “workshop lecture” to assist
  - Meet weekly
  - Grade and hold consulting hours
  - Includes the two peer leaders from the problem solving seminar
Results:
Why did women enroll in PLTL in CS?

41 women responded in 2005-06

60.5%  mailed invitation
15.6%  other
12.8%  info during orientation
9.8%   academic advisor recommendation
9.8%   class announcement
4.9%   parent recommendation
Results - Why enroll in main course?

31 female/49 male responses 2005 (select all that apply)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.0%</td>
<td>22.5%</td>
<td>I received an invitation</td>
</tr>
<tr>
<td>67.7%</td>
<td>28.6%</td>
<td>To see whether I enjoy CS</td>
</tr>
<tr>
<td>29.0%</td>
<td>40.8%</td>
<td>Meets requirement for my major</td>
</tr>
<tr>
<td>25.8%</td>
<td>79.6%</td>
<td>I know I am interested in CS</td>
</tr>
<tr>
<td>19.4%</td>
<td>18.4%</td>
<td>Programming is useful job-market skill</td>
</tr>
<tr>
<td>16.1%</td>
<td>57.1%</td>
<td>I plan to major in CS</td>
</tr>
</tbody>
</table>
Results - Recruiting

• Percentage of women and minorities was higher in ESP-PLTL
• This is over all institutions from 2005-2007.

<table>
<thead>
<tr>
<th></th>
<th>ESP-PLTL</th>
<th>Main Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Female</td>
<td>122</td>
<td>33.4%</td>
</tr>
<tr>
<td>Minority</td>
<td>43</td>
<td>11.8%</td>
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</table>
### Retention Data

<table>
<thead>
<tr>
<th></th>
<th>ESP-PLTL</th>
<th>Non ESP-PLTL</th>
<th>Total (All Students)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Completed</strong></td>
<td>383</td>
<td>2363</td>
<td>2746</td>
</tr>
<tr>
<td></td>
<td>93.2%</td>
<td>88.0%</td>
<td>88.7%</td>
</tr>
<tr>
<td><strong>Dropped</strong></td>
<td>28</td>
<td>323</td>
<td>351</td>
</tr>
<tr>
<td></td>
<td>6.8%</td>
<td>12.0%</td>
<td>11.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>411</td>
<td>2686</td>
<td>3097</td>
</tr>
<tr>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
# Final Grade Data, all Institutions 2005-2007

<table>
<thead>
<tr>
<th></th>
<th>All ESP-PLTL</th>
<th>All Non-ESP-PLTL</th>
<th>Total (All Students)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>B or better</td>
<td>219</td>
<td>80.2%</td>
<td>1130</td>
</tr>
<tr>
<td></td>
<td>1349</td>
<td>70.1%</td>
<td></td>
</tr>
<tr>
<td>Less than B</td>
<td>54</td>
<td>19.8%</td>
<td>522</td>
</tr>
<tr>
<td></td>
<td>576</td>
<td>29.9%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>273</td>
<td>100.0%</td>
<td>1652</td>
</tr>
<tr>
<td></td>
<td>1925</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>ESP-PLTL Female</th>
<th>Non-ESP-PLTL Female</th>
<th>Total (All Females)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>B or better</td>
<td>70</td>
<td>83.3%</td>
<td>295</td>
</tr>
<tr>
<td></td>
<td>365</td>
<td>72.3%</td>
<td></td>
</tr>
<tr>
<td>Less than B</td>
<td>14</td>
<td>16.7%</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>140</td>
<td>27.7%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100.0%</td>
<td>421</td>
</tr>
<tr>
<td></td>
<td>505</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>
Advantages for Peer Leaders (telephone interview)

- Common themes emerged
  - Improved Leadership skills
  - Opportunity to try out educator role
  - Reinforcement of understanding CS concepts
  - Increased confidence to continue in field
  - Friendships with students
  - Would recommend experience to others
Summarizing results

• Active Recruiting increased number of women
  – Email/mailed invitation was most effective
• Retention of PLTL in CS students was higher
• Grades of PLTL in CS students was higher
• Friendships and Bonding occurred with students
• Advantages for Peer Leaders too
• PLTL in CS workshop April 2007 at Duke
Now onto our second project...
Adventures in Alice Programming
Grades 5-12 Outreach

www.cs.duke.edu/csed/alice/aliceInSchools
Adventures in Alice Programming

• Integrate Alice into high school and middle schools by training teachers

• Six sites:
  Durham, NC       Charleston, SC       Virginia Beach, VA
  Denver, CO       Oxford, MS           San Jose, CA

• Durham site focuses on Middle Schools in NC

www.cs.duke.edu/csed/alice/aliceInSchools

Supported by the National Science Foundation Collaborative Grant ESI-0624642, 0624654, 0624528, 0623808, 0624479 and DRL-0826661, two CRA distributed mentor awards, and with additional support from International Business Machines.
Durham: Adventures in Alice site

- Summer 2008
  - 3-week Teacher workshop
    - 35 teachers, mostly middle school, some high school
    - Only a few had every programmed before
    - Subjects: english, math, science, history, art, technology
    - Taught them Alice, Developed Lesson Plans
  - Two one-week middle school camps
    - Taught Alice
    - Lots of time to build their own Alice worlds
  - Overlap between the two
CS Topics Taught

• CS Topics
  – Programming – sequential and “at the same time”
  – Methods
  – Events
  – Looping
  – Conditionals (making a choice)
  – Functions (compute and return an answer)
  – Lists
  – Variables
Other “Fun” Topics Blended in

• Storyboards
• Changing camera views
• Scene changes and lighting
• Making Billboards
• Making objects invisible and visible
• Sounds
• Glueing objects to others
How to Use Alice in Middle Schools

• Teachers
  – Examples in lecture
  – Make interactive quizzes
  – Make worlds on concepts for students to view

• Students
  – Projects (in place of a poster, a model)
  – To take quizzes
  – To view and answer questions about a world
Example Project – How volcano is formed

Today, we are going to see how HOT SPOT volcanoes form.
Deep under the earth's crust heat from the core makes the mantle move like a lava lamp.
How a volcano is formed (slide 3)

Over thousands of years, the volcano builds up...
How a volcano is formed (slide 4)

And emerges above the ocean as an island.
Other Ideas for Projects

- Story from Ancient Egypt
- Spanish Quiz in which you see a word and have to click on the object the word represents
- Animate a scene from a book you have read or a poem you have written
- Create a world about school safety
- Memory game – remember a random color sequence
- Math Quiz – Answer the questions

Alice worlds for these and more are on our website.
Teacher Lesson Plan on quadrant plane

• Click on lighthouse
• Enter x,y position
• Objects randomly move

[Image of a quadrant plane with objects and a question dialog box]

[Question dialog box]

Enter my location as x,y
-3,1

[OK, Cancel buttons]
Other Teacher Lesson Plans

• Math
  – Finding surface area
  – Rate of Change and Slope

• Science
  – Create a food chain
  – Sun, Earth and Moon system
  – Tornados
  – Physics – Newton’s law of gravity
  – Alternative Energy
Other Teacher Lesson Plans (cont)

• History/Social Studies
  – The continents – view world and answer questions
  – Animated overview of Japan
  – Animated overview of Egypt

• English
  – Write and animate a poem
  – Animate a poem or scene from a story
  – Write a movie trailer
How did the Students use Alice?

- Examined worlds to see which concepts they used

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>at least once</th>
<th>3+ times</th>
</tr>
</thead>
<tbody>
<tr>
<td>parameters</td>
<td>34%</td>
<td>17%</td>
</tr>
<tr>
<td>loop</td>
<td>57%</td>
<td>23%</td>
</tr>
<tr>
<td>list</td>
<td>45%</td>
<td>8%</td>
</tr>
<tr>
<td>simple event</td>
<td>57%</td>
<td>34%</td>
</tr>
<tr>
<td>4 arrow event</td>
<td>60%</td>
<td>26%</td>
</tr>
<tr>
<td>if statement</td>
<td>43%</td>
<td>11%</td>
</tr>
<tr>
<td>vehicle property</td>
<td>88%</td>
<td>46%</td>
</tr>
<tr>
<td>camera controls</td>
<td>80%</td>
<td>51%</td>
</tr>
</tbody>
</table>
Feedback from Parents

• “[My daughter] thoroughly enjoyed her week with you. It was a great experience!”
• “I’m convinced. Kids like Alice and Alice is a good way to teach kids programming. [My son] is doing my python course and he’s not all that interested in python and never touches it between the courses. However, in the evenings when he comes home from the Alice course, he works on his Alice worlds.”
Followup

- Teachers use Alice during the school year
- Followup 2-3 day workshop in Summer 2009
- One-week workshops in summer 2009 for additional teachers
- Possible Alice conference in summer 2009
Summarizing

• We developed
  – Tutorials
  – Examples of possible use in Middle Schools
• Teachers developed
  – Lesson Plans for history, science, math, language arts, art, and technology
  – Animation Fair
• Middle School Students
  – Were engaged, developed their own worlds
  – Animation Fair
  – Difficult to get away from the computer

All materials are on our website.
Thanks to my Alice presenters

Henry Qin, Gaetjens Lezin, Jenna Hayes, Ruthie Tucker, Debra Nelson and Don Slater
Web sites

• Peer Led Team Learning in CS
  www.pltlcs.org

• Adventures in Alice Programming
  www.cs.duke.edu/csed/alice/aliceInSchools