Implementation and evolution of PLTL in Introductory Computer Science Courses

Susan Rodger
Computer Science Dept
Duke University

ACS National Meeting
New Orleans, LA
March 20, 2018
Susan Horwitz was the instigator!

• Susan had the brainstorm for integrating PLTL into CS
• Computer Science Professor at University of Wisconsin Madison

• Susan passed away in 2014 from cancer
ESP - Emerging Scholars Program

• Actively recruit incoming first-years
  • Strong Students but at-risk as under-represented groups
    • Women
    • underrepresented minorities
    • Small rural high schools
    • Strong math and science scores

• Meet in small groups to work on challenging problems
PLTL - Peer-led Team Learning

• Doesn’t involve active recruiting
• Offered to all students enrolled in a course
• Group meetings run by undergraduate student leaders
  • Trained to facilitate group learning

• Beneficial to both students and student leaders!
Susan Horwitz’s Idea - PLTL and ESP

• Actively recruit incoming first-years
  • Women
  • underrepresented minorities
  • Small rural high schools
  • Strong math and science scores

• Take intro Computer Science course
  • PLUS Extra hours for working together on challenging problems
  • Led by undergraduate peers

• Goals
  • Increase number of women and underrepresented groups
  • Increase retention and enthusiasm
Getting Started with PLTL

• Susan H. had the idea in Fall 2003
• Got Funding from Microsoft to start at Wisconsin
  • Recruited Spring 2004
  • First Class was in Fall 2004
• Wrote an NSF ITWF proposal in January 2004 that was funded!
8 NSF-FUNDED SCHOOLS

- University of Wisconsin-Madison
- Loyola College
- Beloit College
- Georgia Tech
- Duke University
- Rutgers Scarlet Knights
- Virginia
- Purdue University
Peer-Led Team Learning in CS (PLTL in CS)

- Eight Universities – Fall 2005 – Spring 2008

Beloit College (WI) Purdue University (IN)
Duke University (NC) Rutgers University (NJ)
Georgia Tech (GA) Univ of Wisconsin Madison (WI)
Loyola College (MD) Univ 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.
Training Workshops for 8 Universities

- April 2005 and April 2006
- All met in Wisconsin with our undergraduate leaders
- Two-day training
Enter Pratibha Varma-Nelson!

• Came to our workshop and described how Chemistry has been using PLTL

• We got the Guidebook and Handbook
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
Susan had the brainstorm for integrating PLTL into CS.

Susan passed away in 2004 from cancer.
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
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
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 - Graphs

• 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
Results from Study

• Susan Horwitz, Susan Rodger, Maureen Biggers, David Binkley, C. Kolin Frantz, Dawn Gundermann, Susanne Hambrusch, Steven Huss-Lederman, Ethan Munson, Barbara Ryder, and Monica Sweat, Using Peer-Led Team Learning to Increase Participation and Success of Under-Represented Groups in Introductory Computer Science, Fourtieth SIGCSE Technical Symposium on Computer Science Education, 2009
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>Reason</th>
<th>Female (%)</th>
<th>Male (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I received an invitation</td>
<td>71.0%</td>
<td>22.5%</td>
</tr>
<tr>
<td>To see whether I enjoy CS</td>
<td>67.7%</td>
<td>28.6%</td>
</tr>
<tr>
<td>Meets requirement for my major</td>
<td>29.0%</td>
<td>40.8%</td>
</tr>
<tr>
<td>I know I am interested in CS</td>
<td>25.8%</td>
<td>79.6%</td>
</tr>
<tr>
<td>Programming is useful job-market skill</td>
<td>19.4%</td>
<td>18.4%</td>
</tr>
<tr>
<td>I plan to major in CS</td>
<td>16.1%</td>
<td>57.1%</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></th>
<th>Main Course</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Female</td>
<td>122</td>
<td>33.4%</td>
<td>673</td>
<td>29.0%</td>
</tr>
<tr>
<td>Minority</td>
<td>43</td>
<td>11.8%</td>
<td>218</td>
<td>9.4%</td>
</tr>
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</table>
## Retention Data

<table>
<thead>
<tr>
<th>Retention Data, All Institutions Combined (2005 - 2007)</th>
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</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Completed</td>
</tr>
<tr>
<td>Dropped</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
# Final Grade Data, all Institutions 2005-2007

## Overall Grade Distribution

<table>
<thead>
<tr>
<th></th>
<th>All ESP-PLTL</th>
<th></th>
<th>All Non-ESP-PLTL</th>
<th></th>
<th>Total (All Students)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<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>
<td>68.4%</td>
<td>1349</td>
<td>70.1%</td>
</tr>
<tr>
<td>Less than B</td>
<td>54</td>
<td>19.8%</td>
<td>522</td>
<td>31.6%</td>
<td>576</td>
<td>29.9%</td>
</tr>
<tr>
<td>Total</td>
<td>273</td>
<td>100.0%</td>
<td>1652</td>
<td>100.0%</td>
<td>1925</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

## Gender-Specific Grade Distribution

<table>
<thead>
<tr>
<th></th>
<th>ESP-PLTL Female</th>
<th></th>
<th>Non-ESP-PLTL Female</th>
<th></th>
<th>Total (All Females)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<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>
<td>70.1%</td>
<td>365</td>
<td>72.3%</td>
</tr>
<tr>
<td>Less than B</td>
<td>14</td>
<td>16.7%</td>
<td>126</td>
<td>29.9%</td>
<td>140</td>
<td>27.7%</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100.0%</td>
<td>421</td>
<td>100.0%</td>
<td>505</td>
<td>100.0%</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
Encouraging others in PLTL-CS

• Two-day workshop at Duke in April 2007
  • 73 participants

PI’s at the main schools:
Workshop at Duke April 2007

• College faculty and many brought their peer leaders
19 Additional Universities at the Workshop April 2007

• Univ. of Houston – Victoria
• Columbia University
• Salt Lake Community College
• Univ. Washington Tacoma
• Dartmouth College
• Swarthmore College
• Texas Southern University
• Cal State Univ Dominguez Hills
• Valparaiso University
• Georgia College & State Univ

• Montclair State University
• Worchester State College
• Kean University
• Univ of West Georgia
• Univ North Dakota
• Univ Northern Iowa
• Univ North Carolina
• NC State University
• Univ. Washington, Bothell
Lessons Learned from a PLTL-CS Program

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Serious Fun: Peer-Led Team Learning in CS
Lessons Learned from a PLTL-CS Program

Serious Fun: Peer-Led Team Learning in CS

Using Collaborative, Modified Peer Led Team Learning To Improve Student Success and Retention in Intro CS

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ACS March 20, 2018
Papers on PLTL-CS

Lessons Learned from a PLTL-CS Program

Serious Fun: Peer-Led Team Learning in CS

Using Collaborative, Modified Peer Led Team Learning To Improve Student Success and Retention in Intro CS

USING PEER LED TEAM LEARNING TO ASSIST IN RETENTION IN COMPUTER SCIENCE CLASSES

Carolee Stewart-Gardiner
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Kean University
Union NJ 07083
Papers on PLTL-CS

Lessons Learned from a PLTL-CS Program

Serious Fun: Peer-Led Team Learning in CS

Using Collaborative, Modified Peer Led Team Learning To Improve Student Success and Retention in Intro CS

Using Peer Led Team Learning to Assist In Retention in Computer Science Classes

Learning to Love Computer Science: Peer Leaders Gain Teaching Skill, Communicative Ability and Content Knowledge in the CS Classroom

Sarah Hug
ATLAS Institute. Assessment

Heather Thiry
ATLAS Institute. Assessment

Phyllis Tedford
Texas A&M University
Developed PLTL-CS Resources

- NCWIT – National Center for Women in Technology

National Center for Women & Information Technology
PROMISING PRACTICES

How Do You Retain Women through Collaborative Learning?

Collaborative learning environments require that students work together on formal or informal learning activities. For example, collaborative learning occurs when students work in pairs on programming assignments; when small groups of students discuss possible answers to a professor’s question during lecture; and when students work together outside of class to learn new concepts. Collaborative learning is distinct from projects where students “divide and conquer” the work for an assignment because it requires that they actually work through problems together, that they engage in intellectual talk with each other.

A long tradition of research shows that well-managed collaborative learning environments improve outcomes for all types of students. Outcomes include:

- improved critical thinking
- increased retention, especially for women advancing from the introductory to second course
- appreciation of diversity
- development of social and professional skills

In computer science, collaborative learning environments can improve retention and learning for men and women, and seem to shrink the gender gap in these outcomes. For example, pair programming is one form of collaborative learning with evidence of increased retention of both female and male undergraduates. Other forms of collaborative learning that could succeed in computer science include Peer-Led Team Learning and conversational.

PEER-LED TEAM LEARNING IS A FORM OF COLLABORATIVE LEARNING

Peer-Led Team Learning (PLTL) is a collaborative and active learning technique that forms students in a course into a community of scholars and leads them to take responsibility for their learning. It involves teams of six to eight students that meet weekly in a workshop with a trained peer leader who is under direction of the instructor. During the meeting, the group engages in interesting problem-solving exercises. According to a description of peer-led team learning provided by the PLTL Project at the City College of New York, project evaluations identify six key workshop features:

1. All students in the course must attend the workshops, which are a regular component of the course. This feature encourages students to view the workshop as important to their learning, and integrates...
Developed PLTL-CS Resources

- NCWIT – National Center for Women in Technology

PEER-LED TEAM LEARNING IS A FORM OF COLLABORATIVE LEARNING

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Case Study for Promising Practice

National Center for Women & Information Technology
PROMISING PRACTICES

Peer-Led Team Learning (Case Study 2)
Retaining Women through Collaborative Learning

Lower course drop rates and higher grades are the common outcomes achieved through peer-led team learning (PLTL) in computer science. In addition to advantages for PLTL participants, peer leaders also benefit from this experience, e.g., gaining greater confidence to continue in CS. For example, at the University of Texas at El Paso, weekly training sessions for peer leaders focus on deepening their understanding of cooperative team and professional skills such as conflict management, shared leadership, and techniques for dealing with adversity. These weekly sessions improve the effectiveness of the PLTL sessions, the retention of women, and the development of leaders. One training activity has peer leaders role play a workshop session. The other peer leaders and faculty mentors, who have expertise in cooperative learning techniques, critique the scenario. These training activities allow students to dig deeper into understanding

PLTL “Car Class” Code

```java
Car myCar, yourCar, anotherCar;
int oldSpeed, currSpeed;

myCar = new Car("boop");
yourCar = new Car("honk");
anotherCar = myCar;

currSpeed = myCar.getCurrSpeed();
yourCar.changeSpeed(7);
anotherCar.changeSpeed(20);
currSpeed = myCar.getCurrSpeed();

myCar.blowHorn(2);
yourCar.blowHorn(3);
anotherCar.blowHorn(4);

oldSpeed = currSpeed;
myCar = yourCar;
currSpeed = myCar.getCurrSpeed();

myCar.changeSound("cooga");
myCar.blowHorn(currSpeed/5);
yourCar.blowHorn(yourCar.getCurrSpeed()/2);
```
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anotherCar.changeSpeed(20);
currSpeed = myCar.getCurrSpeed();

myCar.blowHorn(2);
yourCar.blowHorn(3);
anotherCar.blowHorn(4);

oldSpeed = currSpeed;
myCar = yourCar;
currSpeed = myCar.getCurrSpeed();

myCar.changeSound("wooga");
myCar.blowHorn(currSpeed/5);
yourCar.blowHorn(yourCar.getCurrSpeed()/2);
```
Peer Led Team Learning in Computer Science

Welcome

Peer-Led Team Learning (PLTL) involves students working cooperatively in small groups, led by trained undergraduate 'peer leaders'. PLTL has been used successfully for many years in Chemistry and other science courses to improve retention, boost grades, and increase students' enthusiasm for the subject. With funding from NSF, eight universities (listed below with links to their program sites) have been applying PLTL in Computer Science for the past three years.

PLTL in CS sites:

- University of Wisconsin-Madison
- Duke University
- Georgia Tech
- Beloit College
- University of Wisconsin-Milwaukee
- Rutgers University
- Loyola College
- Purdue University

Questions: Send email to Steven Huss-Lederman: huss <AT> beloit <DOT> edu
PLTL-CS web page – pltlcs.org
Search for PLTL-CS Exercises in Computer Science

- Title:
- Language:
  - Alice
  - C++
  - Java
  - Other Languages
  - Any Language (Exercises not for a specific language)
- Topic:
  - Algorithms
  - Code Simulation
  - Concept
  - Games
  - Learning Techniques
  - Logic
  - Programming
  - Team Building
Search for Java – 96 entries

You searched for:

- Title:  
- Language: java
- Topic:
- Keywords:

Results Returned: 96

<table>
<thead>
<tr>
<th>Title</th>
<th>Topic</th>
<th>Language</th>
<th>Creator</th>
<th>Answer for registered user</th>
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</thead>
<tbody>
<tr>
<td>Jeopardy for Basic Programming Review</td>
<td>Other Topic</td>
<td>Java</td>
<td>Susan Horwitz</td>
<td>No answer file.</td>
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</table>

Description
Students play a game to review for the exam.

Materials Needed

ACS March 20, 2018
Since 2007 What has happened to Computer Science?
BS Degrees in CS over the years
Female VS Male

Data from Freshmen Survey trends 1971-2015,
Cooperative Institutional Research program, Higher Ed.
Research Institute, UCLA
Enrollment Growth in CS Majors

- From CRA report “Generation CS: Computer Science undergraduate enrollment surge since 2006”.

Figure B.1: Average number of CS majors per unit since 2006.
Growth of CS Students Vs CS Faculty

What has happened to Introductory Computer Science?
CompSci 101, Fall 2017

Home

CompSci 101: Introduction to Computer Science

Course Description

Introduction to practices and principles of computer science and programming and their impact on and potential to change the world. Algorithmic, problem-solving, and programming techniques in domains such as art, data visualization, mathematics, natural and social sciences. Programming using high-level languages and design techniques emphasizing abstraction, encapsulation, and problem decomposition. Design, implementation, testing, and analysis of algorithms and programs. No previous programming experience required.
CompSci 101 at Duke in 2017-18

- Enrollments per semester around 300
- 40 Undergraduate Teaching Assistants (UTAs)
- Still in Lecture and lab format
- About 18 labs, each run by 2 Undergraduate Teaching Assistants (UTA) (peer leaders)
- They are trained each week on the lab on Monday or Tuesday, then they run the lab on Wed or Thurs
- UTAs hold consulting hours at night 7pm-11pm
- They help grade the exams
- 50% female in this first course
  - drops to 30% female in second course
  - Large number of males skip the first course
Things have changed a lot with the growth in enrollments

• We don’t need to attract students to CS
• But we do still need to attract women and underrepresented groups to CS
• Our understanding of PLTL was quite helpful as we have adapted it to our growth in enrollments!