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Beyond Robots

A SMÖRGÅSBORD OF INTRODUCTORY COMPUTER SCIENCE EXPERIENCES

FUNDING PROVIDED BY THE NATIONAL SCIENCE FOUNDATION UNDER GRANT #BPC-05-40549

PRESENTED BY MATTHEW K. MEYER ELIZABETH SKLAR BRIDGES TO COMPUTING BROOKLYN COLLEGE SPRING 2011
Introduction

- Recent trends in computer science teaching have advocated the use of **context-based curriculum** (games, robots) to capture students diverse interests.
- Over the last five years the Bridges To Computing Program at Brooklyn College has developed a wide variety of contextualized curriculum units and implemented them in multiple courses offered to inner-city students.
- In this presentation we discuss our program, the **free reusable curricular modules** we have developed and lessons we have learned from our diverse student population.
- Our goal is to broaden the pool of curricular **resources available to high school computer science teachers**.
About Us

- The Bridges Program
- College Now Partnership
- Our Students
Bridges Program

- Started in 2005 through a BPC grant from the National Science Foundation, the Bridges to Computing project focuses on the transition years from high school to college, working to prepare students for careers in computing fields.
- Bridges involves both academic and social components geared toward advanced high school students, and early and advanced college students.
- At the high school level, the Bridges Program (now in partnership with the Brooklyn College/CUNY College Now Program) offers 3 different courses to high-school students for high-school science credit.
- In 2012, we will begin offering courses for college credit.
Professor Elizabeth Sklar,  
Principle Investigator (PI) of the Bridges to Computing Program  
Brooklyn College, CUNY

Professor Ira Rudowsky,  
Co-PI of the Bridges to Computing Program  
Brooklyn College, CUNY

Professor Samir Chopra,  
Co-PI of the Bridges to Computing Program  
Brooklyn College, CUNY

Professor Simon Parsons,  
Co-PI of the Bridges to Computing Program  
Brooklyn College, CUNY

Matthew K. Meyer  
Primary Instructor for the College Now - Bridges to Computing Program, Adjunct Faculty Brooklyn College, CUNY

Jeffery Raphael  
Instructor for the College Now - Bridges to Computing Program, Adjunct Faculty Brooklyn College, CUNY

Kenneth Auyeung  
Project Coordinator for the Bridges To Computing Program Brooklyn College, CUNY

Chipp Jansen  
Project Coordinator for the Bridges To Computing Program Brooklyn College, CUNY

Valerie Andrewlevich  
Instructor for the College Now - Bridges to Computing Program, Project Coordinator for the Bridges To Computing Program Brooklyn College, CUNY
Starting in 2010, funding, operating and recruiting responsibilities for Bridges high-school classes were gradually transferred to the College Now Program at Brooklyn College (this transition was completed in 2011). Students who pass a Bridges course now receive their high school science credit through the CUNY College Now program (rather than through Brooklyn College).
Since Summer 2006 Bridges has:
- taught more than 300 high-school students.
- reached over 60 public high-schools in Brooklyn.
- Most students have little to no previous exposure to computing as a *science*.
- Many participants are first in their family to attend college.
- Students complete an application and survey.
- Participants are largely immigrants.
Some student statistics...

Parental Ethnicity

Summer Workshop - Attendance by School

Summer Workshop - Students Attending (by gender)

Do you think you are GOOD with computers? (Spring 2011)

Students by Grade

Student Ethnicity (self-identification)
Our Mission

• The Problem
• Challenges
• Our Goals
The Problems

- We face a **desperate national shortage** of computer scientists and engineers [1, 2].
- Computer Science is not considered a core subject by Federal standards (e.g., No Child Left Behind); this has a major negative influence on school budgets and priorities.
- The number of high schools teaching Computer Science is **shrinking**, and nationwide less than 20,000* students sat the AP test in 2010 (The AP/AB test was discontinued in 2009). [3]


* By comparison 245,867 students took the AP Calculus AB with another 78,998 taking the AP Calculus BC exam in 2010.
Challenges

1. Computer Science at any level, not just AP level, is **ABSENT** from the curriculum in most high-schools.

2. Introductory programming students (in college and high-school) often **drastically overestimate their own skills** with computers*.

3. Introductory "command line" programming classes seem removed from students' daily experience with computers --- and thus of questionable value to them.

4. Computer Science has an **image problem**, that in particular hurts the recruiting of women and minority students [5].

* When asked why they think they are "GOOD" with computers they often reply that they are on Facebook and Twitter and can text.

4. The Image Problem

**Then**

Readin n' writin? That's for city folk.

**Now**

Computers? They're for nerds.
Our Goals

1. Breakdown preconceived notions about computer science by focusing on the interdisciplinary nature of computer science skills and how such skills can "help students achieve their own personal goals".

2. Prepare high-school students for college-level (AP) programming courses by introducing them to:
   - Programming languages and paradigms.
   - Computer hardware fundamentals.
   - Binary mathematics and Boolean logic.
   - Computer networks and protocols.

3. Get meaningful (not necessarily AP) computer science education into high schools.
Our Curriculum Units

WHY SO MANY CURRICULUM UNITS?

• SUPPORT UNITS
• PROJECT UNITS
Why so many topics?

- The Bridges Program has developed 10 support units and 8* project units that we can draw upon to create our courses (we are always looking to add more **).
- Why not focus on a single context (games, robots)?
  - Our research has shown a significant number of students view robots as "toys", and are not motivated by them.
  - Likewise a significant percentage dislike computer games.
  - NO SINGLE TOPIC has been found that didn't turn off some percentage of students.
- Offering choices has been a rewarding strategy!

*Two additional project units are in development.

**NOTE: For us, a project or support unit CANNOT just be about learning how to use a particular piece of software (Photoshop) but must serve one of our larger goals.
NOTE: Not all project options were made available each year. But for each year, if a project option was available some students would choose it. There was never a year when a project option was made available and nobody chose it.
Support Units

- **Support units** are designed to be incorporated into one or more project units, and cover **key concepts** that serve to fulfill a course's educational goals.

- Support units are composed of 1-2 lectures and a lab or quiz.

  - **Unit S1: Careers in Computing**
  - **Unit S2: The (Brief) History of Computer Science**
  - **Unit S3: Electricity & Binary Numbers**
  - **Unit S4: Introduction to Computer Hardware**
  - **Unit S5: Introduction to Computer Programming**
  - **Unit S6: Introduction to Operating Systems**
  - **Unit S7: The Internet and World Wide Web**
  - **Unit S8: Cybercrime - How to protect yourself**
  - **Unit S9: Visual Programming Languages**
  - **Unit S10: Introduction to Interface Design**
Changing Attitudes

- **Unit S1: Careers in Computing**
  - Leveraging students life goals to teach them CS.

- **Unit S2: The (Brief) History of Computer Science**
  - Demonstrating the diversity in computer science.

- **Unit S8: Cybercrime**
  - How to protect yourself
  - Getting students to rethink Internet usage in their lives.

- **Unit S9: Visual Programming Languages**
  - "VPLs are not toys". Practical reasons for using VPLs.

- **Unit S10: Introduction to Interface Design**
  - Building better websites and more compelling games!
Essential Skills

- **Unit S3: Electricity & Binary Numbers**
  - It's not magic! How computers actually work.

- **Unit S4: Introduction to Computer Hardware**
  - A+ certification and "bare bones" systems.

- **Unit S5: Introduction to Computer Programming**
  - Syntax, Semantics & Paradigms (Imperative, Procedural, OO)

- **Unit S6: Introduction to Operating Systems**
  - Programs, APIs, Security & Scripting.

- **Unit S7: The Internet and World Wide Web**
  - History, technology (protocols) tools.
**Project Units**

- **Project units** are designed to be short stand-alone "project based learning" curriculum modules.
- Project units are composed of 2-3 lectures and 2-3 labs and conclude with a large student project assignment.

**Unit P1: PC Hardware and A+ Certification**
**Unit P2: Intro to Robotics (RCX & RoboLab)**
**Unit P3: Intro to Game Programming and Design (SCRATCH)**
**Unit P4: Intro to Web Programming and Design (XHTML & CSS)**
**Unit P5: Intro to Graphics & Interactive Programming (Processing)**
**Unit P6: Introduction to Cryptology (PGP)**
**Unit P7: Intro to Network Security (Wireshark, NMap)**
**Unit P8: Intro to GPS and GIS (Google Earth, Google Maps, ManyEyes)**
Programming Project Units

- **Unit P2: Intro to Robotics (RCX & Robolab)**
  - Basic (Imperative) programming. Final Project (FP) = RoboCupJunior.

- **Unit P3: Intro to Game Programming & Design (SCRATCH)**
  - Basic programming (sprites as objects). FP = Design/create own game.

- **Unit P4: Web Programming & Design (XHTML & CSS)**
  - Markup languages, Interface design. FP = Multi-page website using CSS.

- **Unit P5: Graphics & Interactive Programming (Processing)**
  - Basic programming (Imperative/Procedural) Vector & Bitmap images. FP = Design/create interactive animation.

- **Unit P9: Agent Based Programming (NetLogo)**
  - Alternative Syntax, Basic programming (Imperative/Procedural/Agents), Simulations. FP = Model a problem or create a simulation.
Research Project Units

- **Unit P1: PC Hardware and A+ Certification**
  - "Bare bones" system components, A+ certification. Life of a systems admin. FP = Computer Autopsy + Computer Reanimation

- **Unit P6: Introduction to Cryptology (PGP)**
  - History of cryptology (alpha-numeric ciphers), modern cryptology (SKC, PKC, HASH). FP = Paper or Presentation on Topic in Cryptology.

- **Unit P7: Intro to Network Security (Wireshark, NMap)**

- **Unit P8: Intro to GPS & GIS (Google Earth, ManyEyes)**
  - History of navigation (longitude, latitude), modern GPS (and applications) GIS and other data visualizations. FP = Google Earth Tour, or GIS map relating to problems in their neighborhood.
Courses

• COURSE CONSTRUCTION
• SUMMER / FALL / SPRING
• PROJECT BASED CURRICULUM
• WEBSITE AND COURSEBOOK
Course Construction

- All Bridges classes are created by linking together 3 or more project units together with support units.
- Two of the units are usually programming units and the 3rd is usually a research unit.
- In any Bridges class, we try address the following:
  - Reframe student views about computing as a science, and an interdisciplinary field.
  - Programming languages and paradigms.
  - Computer hardware fundamentals.
  - Binary mathematics and Boolean logic.
  - Computer networks and protocols.
Summer Institute

2010 [Syllabus] 44hrs + 2 hour student showcase

- **Week 1 (3 days @ 4hrs):**
  - Taster Sessions (2hr topic introductions lecture/lab)
    - Web Programming and Design (required project)
    - Robotics, Game Programming, Cryptology (project choices)
  - Careers in Computing & Campus Tour

- **Week 2 (4 days @ 4hrs):**
  - Robotics, Games and Network Security as well as Web Design
  - Brief History of Computer Science

- **Week 3 (4 days @ 4hrs):**
  - Website Work, (Other topics like GPS & GIS, Computer Music)
  - Project Selection & Completion (Robotics, Games or NetSec/Cryptology)
  - Student Showcase (parents invited)
  - Final Projects are incorporated into the students websites (USB)
Fall and Spring Offerings

**FALL (HS Credit)**

- **Support Units**
  - Unit S1: Careers in Computing
  - Unit S2: The (Brief) History of CS
  - Unit S3: Electricity & Binary Numbers
  - Unit S4: Intro to Computer Hardware
  - Unit S6: Intro to Operating Systems
  - Unit S5: Intro to Programming
  - Unit S7: The Internet & WWW
  - Unit S8: Cybercrime

- **Project Units**
  - Unit P1: PC Hardware and A+ Certification
  - Unit P2: Intro to Robotics (RCX & Robolab)
  - Unit P6: Introduction to Cryptology (PGP)
  - Unit P7: Intro to Network Security (Wireshark, NMap)

**SPRING (College Credit 2011)**

- **Support Units**
  - Unit S5: Intro to Programming
  - Unit S7: The Internet & WWW
  - Unit S9: Visual Programming Languages
  - Unit S10: Introduction to Interface Design

- **Project Units**
  - Unit P4: Intro to Web Programming and Design (XHTML & CSS)
  - Unit P5: Intro to Graphics & Interactive Programming (Processing)
  - Unit P9: Introduction to Agent Based Programming (NetLogo)
  - Unit P3: Intro to Game Programming and Design (SCRATCH)
Project Based Curriculum!

In all our classes the focus is on project-based learning and students create large projects/presentations in each class.
**College Partnership:**

- The *College Now - Bridges to Computing* program is able to offer multiple courses at fairly low cost partially because of resources made available through Brooklyn College.
- We, in turn, have posted our materials (lectures, labs and lesson plans) on-line (for free).

**Web site:**

- [http://bridges.brooklyn.cuny.edu](http://bridges.brooklyn.cuny.edu)

**Course Book:**

- We are producing a book (similar format to *Exploring Computer Science*) with our materials.

*Goode and Chapman, Exploring Computer Science, Computer Science Equity Alliance, 2009.*
Thank you!

Questions? Please feel free to contact us:
- Matthew Meyer meyer@sci.brooklyn.cuny.edu
- Elizabeth Sklar sklar@sci.brooklyn.cuny.edu

http://bridges.brooklyn.cuny.edu
Introduction:

- Seven of 19 listings in Fortune magazines “Fastest-Growing Professional Jobs” were Computer Science related positions.
- The USBL S [1] is projecting four times as many new jobs as computing as in all other engineering areas combined.
- The average number of new computing jobs created per year is double the average number of computing graduates.
- Computing is the only STEM discipline in which demand for graduates exceeds supply. [2]
- Computer Science is not considered a core subject by Federal standards (e.g., No Child Left Behind); this has a major negative influence on school budgets and priorities.
- Many high schools are unable to offer Computer Science classes because of lack of materials and/or expertise.
- The number of high schools teaching Computer Science is shrinking, and nationwide less than 20,000 students sat the AP test in 2010 (The AP/Act test was discontinued in 2000). [3]

Summary:

Recent trends in computer science teaching at the introductory level have advocated the integration of context-based examples to capture students’ diverse interests and expose them to a range of computing applications. 

Over the last 5 years, we have developed and implemented a wide range of contextualized curricula modules in courses offered to inner-city high school students. In all of these modules, we focus on the use of free software tools in order to minimize costs and maximize students’ access to tools outside the classroom. All modules are composed of student-centric hands-on activities, with limited lecture time. A single Bridges high school course merges 3 or more modules. The aim is for students to become comfortable with a range of uses for computing applications and begin to absorb the tenets of computational thinking.

We have identified several advantages to using this indirect, mixed-match approach. First, it acknowledges that not all topics will interest all students, and increases the likelihood of each individual student finding a topic that interests her/him. Second, it allows students to have multiple hands-on, project-based experiences exploring the breadth of a single academic subject—computing—within one course. Finally, by exposing students to the wide range of topics encompassed by the ever-expanding sub-fields within computer science, our approach helps break down any preconceived notions among students about what it means to be a computer scientist.

The Bridges Project:

The Bridges to Computing project focuses on the transition years from high school to college, and works to inform students about and prepare them for careers in computing fields.

Over the last 5 years, the high school component of the Bridges project has reached more than 300 students from nearly 60 public high schools in Brooklyn and around New York City.

Funding provided by the National Science Foundation under grant #BPC-05-40549

Computer Science Courses:

Bridges’ offerings for New York City public high school students include: (1) Does It Compute?, an intensive 11-day summer workshop which is available to all NYC high school students, as well as (2) Bridges I and (3) Bridges II, two courses offered in the Fall and Spring respectively. Currently limited to students from Brooklyn College/College Now partner high schools.

Students who pass a Bridges course receive a high school science elective credit through a partnership with the CUNY College-Now program (http://collegenow.cuny.edu).

Curriculum Project Units

The modular Project Units we have created are composed of 1-3 lectures, 1-3 labs, 1 or more homework assignments and a final “unit project”.

Our course curricular modules include:

(1) Web Programming & Design
(2) Game Programming and Design
(3) Robotics
(4) PC Hardware and A+ Certification
(5) Cryptography
(6) Network Security
(7) GPS and GIS Systems
(8) Introduction to Graphics Programming
(9) Agent-Based Simulation

We have also created Support Units to help prepare and reinforce topics that are covered in the Project Units.

Future Work

The Bridges program is seeking academic, industry and government-funded partnerships to expand our successful program to other high schools, colleges and universities around New York state. In addition, we are working towards college credit high-school courses through College Now, and continuing to offer free high school teacher computer science workshops, in partnership with the ACM CSTA.

For further information, please contact: Prof. Elizabeth Sklar, PI

The Project Team includes: Co-PI’s - Professors Simon Parsons, Ira Rudowsky and Samir Chopra; Instructors/Staff - Matthew K. Meyer, Jeffery Raphael, Chipp Jansen, Valerie Andrewlevich, and Kenny Auyeung; Graduate Student Mentors; Undergraduate Student Mentors and Project Evaluator Dr. Susan Lowes.