Bridges to Computing: Final Project Report

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1 Overview

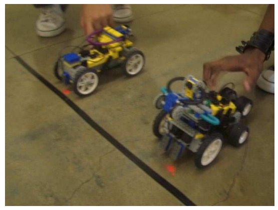
The **Bridges to Computing** project at Brooklyn College of the City University of New York (CUNY) focused on the transition years from high school to college, working to better inform students about and prepare them for careers in computing fields. *"Bridges"* involved academic and social components geared toward advanced high school students, and early and advanced college students. The project had three primary aims, each focused on a particular target group. These are outlined below:

Aim #1—High School
To develop and implement introductory computing courses for high school students, with the goal of being able to offer for-credit courses to New York City public school students in the summer and during the academic year.

Aim #2—Undergraduate
To develop and implement "flavored" versions of introductory computing courses for undergraduates, with the goal of using a hands-on, contextualized approach to integrate topics such as robotics and games into traditional programming curricula (e.g., "CS1" and "CS2") and to create interdisciplinary courses that introduce computer science concepts to non-majors.

Aim #3—Mentoring and Community Building
To provide tiered mentoring to high school and undergraduate students, and outreach to the community, with the goal of having undergraduate "Ambassadors" mentor high school students, graduate students mentor undergraduates, faculty mentor students at all levels, and project participants at multiple levels reach out to the community in a variety of ways.

Over the five years of the project's extended funding period, Bridges reached approximately **400 students (48% female; 43% Black, 27% Hispanic)** from **70 NYC public high schools** in Brooklyn, Manhattan and the Bronx, **over 3000** undergraduates through **158** sections of **18** newly developed or updated computing courses, and **32 undergraduate Ambassadors**. Most participants (high school students and undergraduates) were immigrants from the Caribbean, Asia (China and the Indian subcontinent), and Eastern Europe. Most CUNY students work part-time while attending school full-time.

This report highlights the outcomes achieved during the course of the project and emphasizes those components that have been successfully institutionalized, i.e., continuing beyond the end of project funding. Lessons learned by project PIs are detailed. The report concludes with comments about future directions and recommendations.

Ten major results have been achieved by the Bridges project. These are outlined below:

Aim #1—High School

1. Two computing courses for high school students have been institutionalized as part of CUNY's *College Now* program (`http://collegenow.cuny.edu`). *Computing Prep* is a course offered each semester and also in the summer. NYC public high school students who complete the course receive one high school science elective credit. *Introduction to Multimedia Computing* (see below) is a course offered once a year and is open to NYC public high school students who have successfully completed the *Computing Prep* class. *Introduction to Multimedia Computing* is offered at the college level, for 3 credits.
2. The high school curricula developed by the project has been presented in workshops to the Computer Science Teachers Association (CSTA) community[5]. The material has been compiled into a booklet (formatted similarly to *Exploring Computer Science* [3]), for easy distribution. Eight teachers participated in this workshop.

Aim #2—Undergraduate

3. *Flavored* versions of an introductory programming course for undergraduates have been developed and are offered at Brooklyn College each semester as the first course for students intending to major in any computing discipline (*Computer Science*, *Multimedia Computing*, *Information Systems*, and *Computational Math*). The two most successful "flavors" are *robotics* (average enrollment of 19 students per term) and *gaming* (average enrollment of 26 students per term).
4. An introductory-level interdisciplinary course for undergraduates called *Exploring Robotics* was developed and is offered at Brooklyn College each semester as an elective course that fulfills general education requirements; this course has no prerequisites and does not require any background in computing, programming, or robotics. This course is extremely popular, and the annual enrollment averages 212 students.
5. An introductory-level interdisciplinary course for undergraduates called *Introduction to Multimedia Computing* was developed and is offered at Brooklyn College each semester as the first course for students intending to major in *Multimedia Computing*. This course has no prerequisites and does not require any background in computing or programming. This course is also popular, with an average enrollment of 21 students per term. One section of this course is also offered to high school students through the CUNY College Now program (see above).

Aim #3—Mentoring and Community Building

6. Undergraduate Ambassadors participate as teaching assistants in the CUNY College Now high school summer program. Originally, these students were funded through stipends as part of the Bridges budget. Now they are funded by College Now.
7. Undergraduate peer-tutoring within the Computer and Information Science (CIS) department at Brooklyn College has been given dedicated space, establishing the *Computing Resource Center*, where peer-tutoring is available $40+$ hours per week. Tutors are advanced undergraduate majors who participate to fulfill the service-learning component of an independent project degree requirement. On average, more than 60 students per term use this space for tutoring.
8. A recurring event called *Tea with Professors* was established within the CIS department to bring faculty and students together in an informal setting for discussing a wide range of topics, such as career options in computing and pathways to graduate school. Speakers from industry and research institutions across the country have been invited to present their work and talk with students. More than 600 students have attended *Tea* events.
9. Project activities are showcased in the community through two types of events. As part of the College Now summer workshop for high school students, an evening Showcase event takes place in which parents and families are invited to view posters and demonstrations of student work. As part of regular Brooklyn College open houses, demonstrations are offered that exhibit interdisciplinary (robotics and multimedia/games) work of current students. More than 400 students have presented their work to parents and prospective students.
10. Successful experiences with faculty mentoring undergraduate research projects led to an academic year Research Experiences for Undergraduates (REU) Site project[1]. This grant is helping to sustain funded undergraduate research. To date, 27 students have received funding through this REU Site project.

Six conference and journal publications have been published describing various aspects of the project [5, 7, 10, 1, 8, 9].

The Bridges project was initially funded in March 2006. No-cost extensions were granted in March 2009 and March 2010, to carry the project through May 2011. The activities of the final two no-cost extension years were focused on institutionalizing the successful components of the project. The Principle Investigator for the project was Professor Elizabeth Sklar, Brooklyn College. The Co-PIs, all of Brooklyn College, were Professor Simon Parsons, Professor Ira Rudowsky and Professor Samir Chopra[2]. The remainder of this report provides details on the activities and the achievement of each of the outcomes listed above.

[1] *REU Site: MetroBotics: undergraduate robot research at an urban public college*, NSF CNS #08-51901, 7/2009–6/2012

[2] Note that Professor Lori Scarlatos (Stony Brook University) was the PI for the first 6 months of the project, and Sklar was a Co-PI; then Scarlatos left Brooklyn College for another position and resigned from the project.

2 High School Activities

Since Summer 2006, the Bridges team has offered programs to New York City public high school students, during the summer and the academic year. The summer activity is the *Does it Compute?* Summer Workshop. The academic year activity is the *Computing Prep* course[3]. This section describes each of the following aspects of the project's high school related activities:

- Development of Curricular Modules
- Lessons Learned
- Recruitment
- Dissemination
- Institutionalization and Sustainability
- Evaluation

2.1 Development of Curricular Modules

The *Does it Compute?* and *Computing Prep* courses delivered to high school students through the Bridges project, both during the summer and academic year, are comprised of multiple curricular modules. Each module is a stand-alone, project-based learning unit that can be customized for different students, instructors and settings. Recurring educational themes have been woven into each of the modules including: the basics of imperative, procedural and object-oriented programming; the fundamentals of computer hardware; and the exciting employment and research opportunities that exist within the many sub-fields of computer science. Units are conducted through student-centric hands-on activities, with limited lecture time. 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, mix-and-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 within one course. Finally, by showing students the wide range of topics encompassed by the ever-expanding field of computer science, it helps break down preconceived notions among students about what it means to be a computer scientist.

Each course (summer and academic year) is created by selecting multiple full-length *Project Units*, accompanied by several shorter *Support Units*. Collectively, these units cover a diverse range of computer science subjects. Each Project Unit includes 1-3 lectures, 1-3 labs, 1 or more homework assignments and a final "unit project". The Project Units are:

- **Web Programming and Design:** This module introduces students to the concept of markup languages (encoded metadata) and presentational, procedural and semantic markup. Students learn to use XHTML to create web-pages and to use CSS to keep formatting and style decisions consistent over an entire website. Finally, students explore client side scripting using JavaScript, and discuss the concept of dynamic webpages created by server side scripting. For their final projects, students create their own unique websites using XHTML and CSS (`http://www.w3schools.com/`).

[3]Starting in Spring 2012, the undergraduate-level *Introduction to Multimedia Computing* course will also be offered to high school students.

- **Game Programming and Design:** This module introduces the science and art of programming and designing games, including essential topics in formal game design (Ludology) and storytelling (Narratology). Armed with the knowledge of what makes a good game, students then explore the mathematical problems and complexity issues that arise when trying to create realistic physics in a game (collision detection and response). They are introduced to concepts such as storyboarding, finite state machines, character sprites, and behavior based modeling, which leads to discussions of artificial intelligence and game theory. For their final projects students create their own games using Scratch (`http://scratch.mit.edu/`).

- **Robotics Programming and Design:** This module describes fundamental aspects of robotics and gives students hands-on experiences programming physical robots. They learn about sensors, actuators and robot controllers. They construct robot bodies using LEGO Mindstorms [4] and program robot brains using RoboLab [11, 2]. A series of short labs introduce topics such as event handling, touch sensors, light sensors, and parallel processing. For their final projects, students design and program small robots to solve a variety of simple tasks based on RoboCupJunior challenges [6].

- **PC Hardware and A+ Certification:** This module provides a brief overview of A+ certification (`http://www.comptia.org/`) and the physical components of a "bare bones" computer system. The final project is a "computer autopsy", where students disassemble old discarded machines, and then try to reassemble them sufficiently to reach the BIOS screen.

- **Cryptography:** This module introduces cryptography (writing secret messages), cryptology (breaking secret codes) and technologies such as symmetric-key, public-key, and certificate systems. For their final projects, students use GNU's free OpenPGP tool to create their own public/private key set, allowing them to send and receive email messages that only their chosen friends can read. This topic provides a context for discussion of privacy in social networks (`http://www.gnupg.org/`).

- **Network Security:** This module introduces the technologies that underly the Internet and the World Wide Web, focusing on the Internet Protocol Suite (Application, Transport, Internet and Link layers). In the unit project, students use Wireshark to eavesdrop on messages sent over an unencrypted network, and NMAP to scan the ports of a target machine. This module introduces and enforces the principles behind the "ethical hacker" movement (`http://www.wireshark.org/` and `http://nmap.org/`).

- **GPS and GIS Systems:** This module explains latitude and longitude and details how the modern satellite-supported GPS system works. Students study GIS, and learn how GPS data can be used to display geographically linked information on maps. For their final projects, students use Google Maps and GIS concepts (they may also use cameras) to create maps to illustrate problems/ possibilities in their own neighborhoods (`http://maps.google.com/`).

- **Introduction to Graphics Programming:** This unit introduces the basic terminology used in 2D computer graphics (e.g., bitmaps, vector images, hex colors), and interactive programing, covers multiple techniques for creating animated images and establishes the conceptual framework used to create 3D images. In the final project, students create interactive, animated graphics programs using Processing (`http://www.processing.org`).

- **Agent-Based Simulation**: This module introduces agents, agent-based programming and multi-agent simulation. Students are shown how interacting agents pursuing individual goals can accomplish complex tasks, and how agent-based programming can help manage complexity in large problems. Simulations of systems in the everyday world are discussed (traffic patterns and social networks). In the unit project, students design and create programs that model well-defined problems or phenomena using NetLogo (`http://ccl.northwestern.edu/netlogo`).

Each Support Unit includes 1-2 lectures and are designed to accompany one or more project units. The Support Units are:

- **Careers in Computing:** A quick introduction to the vast array of careers that require individuals to have computer science skills, and the numerous industries that rely on computer scientists and engineers.
- **The (Brief) History of Computer Science:** This short unit discusses the evolution of the modern computer and are introduced to such luminaries as Ada Lovelace, Charles Babbage, Grace Hopper and Alan Turing.
- **Electricity and Binary Numbers:** This short unit briefly outlines what a CPU actually does and how it does it. Two lectures cover the most basic aspects of discrete digital operations. This unit supports the PC Hardware project Unit.
- **CyberCrime–How to protect yourself:** This short unit raises several questions that students should be aware of in today's digital world: What is CyberCrime? What is identity theft? How can I protect myself? This unit supports the Cryptography and Network Security project units.
- **Introduction to Computer Programming:** This short unit explains at an abstract level what a programming language is. Brief lectures introduce the basic concepts behind (and handy mnemonics for remembering) the Imperative, Procedural and Object Oriented programming paradigms. This unit supports the several of the Project units.

Table 1 lists the curricular modules that have been offered each session.

2.2 Lessons Learned

Over the 5 years of offering courses to high school students, many lessons were learned by the project team regarding the management of students in this age group. At times, we realized that we had to choose between making the time students were in our classrooms "fun" or "educational"; although our ultimate goal was always to do both, any teacher knows that such a goal is unrealistic. We made a conscious decision in our summer workshop to opt for "fun" over "educational" for three reasons. First, we knew that students were choosing to spend their summer holidays in our classrooms, and we did not want attending the workshop to feel like a chore—otherwise, we knew that students would not keep coming back for the duration of the workshop. Second, we wanted students to remember their experiences fondly after the summer was over so that they might take our academic-year course and that they might consider majoring in computer science in college. Finally, given the amount of material students were being exposed to, we were confident that they could not help but absorb some computer science—as long as they stuck with the program.

Key to the structure of our courses was the understanding on our part that most classroom experiences for our students last approximately 45 minutes—the standard length of a class period in New York City public

Table 1: Schedule of Curricular Modules Offered

	summer						*academic*
	2006	2007	2008	2009	2010	2011	*year*
Web Prog./Design	x	x	x	x	x	x	x
Game Prog./Design		x	x	x	x	x	x
Robotics	x	x	x	x	x	x	x
Hardware/A+ Cert.					x	x	x
Cryptography	x	x	x	x	x	x	x
Network Security						x	x
GPS and GIS				x	x	x	x
Graphics Prog.	x						x
Agent-based Sim.	x	x	x				x
Careers					x	x	x
History of CS					x	x	x
Electricity							x
CyberCrime							x
Programming							x

high schools. Some science classes have "double lab periods" once or twice a week, but even those last only 90 minutes. The idea of students coming into our classroom and spending 2 hours on one topic was daunting to them when they first started our courses. So, we designed our courses to keep students active and engaged throughout each session. Both the summer workshop and the academic-year courses are organized in 2-hour blocks, with breaks for food in between.

Over the 6 years that we have offered a summer workshop, the length of the workshop has varied from 8 to 11 days. Each day was divided into one 2-hour session in the morning, followed by one hour for lunch, then either a long 3-hour project session or two split sessions in the afternoon. In both 8-day and 11-day forms of the summer workshop, students spend the first two and a half days attending 2-hour "Taster" sessions on a range of different topics. Then they spend the remaining days in "Pick" sessions, where they choose one topic in which to do an in-depth project. The longer, 11-day workshop integrates additional Taster sessions (content was chosen from the Support Units described above) during the latter portion of the workshop, alternating with Pick sessions (e.g., new Taster session in the morning and recurring Pick session in the afternoon). In addition, students were given information about applying to college, from the Brooklyn College admissions office, as well as a campus tour. We found that, for many students, coming to the Brooklyn College campus to participate in the Bridges courses was their first experience ever stepping onto a college campus.

The academic year class was a challenge, until we integrated the program with College Now (starting in Fall 2010). Prior to that time, the academic year was offered as a 2-hour session, after school, once a week. Students who attended were primarily those who had completed the summer workshop in the previous summer and wanted more in-depth experiences. We were generally unable to offer academic credit (unless special arrangements were made with individual high schools). The collaboration with College Now solved many logistical problems, and the ability to offer course credit consistently was one of the more significant results. The academic year class was then shifted to run on Saturdays, along with other courses (in other disciplines) offered by College Now. Another change was to lengthen the courses, to comply with a 54-hour requirement for courses that provide a high school course credit.

Feeding high school students was always an issue. Having CUNY College Now take over the workshop meant that their staff took care of lunches, which meant that we could focus on academic issues and not have to dedicate resources (funding or staff) to feeding students. Before 2011, however, we had to get funding (primarily collected from various college resources) to provide lunch for students each day during the summer workshop, and we had to designate 1-2 staff members each day to handle ordering food and cleaning up after lunch. We did not provide food during the academic year class before the involvement of College Now. At that point, the academic year class shifted from an after-school class to a Saturday class.

2.3 Recruitment

Three methods of recruitment have been used for attracting high school students to our programs:

1. *Small-scale, visits to schools (2006 and 2007):*
   Recruitment was done by a Brooklyn College employee who visited a small number of targeted high schools and spoke to teachers, guidance counselors and students about the program.

2. *Large-scale, mass mailing (2008 and 2009)*:
   Recruiting was done by generating a mass mailing of glossy color flyers sent to every public high school principal in Brooklyn and Lower Manhattan, accompanied by a cover letter explaining the program and asking principals to pass on the information to guidance counselors, teachers and students.

3. *Medium-scale, through established relationships with schools (2010 and 2011):*
   Recruitment in 2010 and 2011 was done by College Now staff, who have ongoing relationships with high schools throughout Brooklyn. They distributed applications to high schools around Brooklyn and lower Manhattan. They screened applications[4] and provided Bridges staff with a list of students.

We can evaluate the recruiting methods by comparing the number of applications accepted[5], the number of students who attended at least one day, the number of students who completed the workshop, and the percentage of female students. Table 2 shows, for each year of the Bridges Summer Workshop, the number of students who were accepted, attended (at least once) and finished (attendance rate at least 75%).

Figure 1 illustrates the recruiting numbers graphically. Each graph contains groups of bars, where each bar contains the data for one year. The bars are ordered chronologically, with numbers for 2006 on the far left and numbers for 2011 on the far right. The bars in graphs (a) and (b) are grouped into three sets. The leftmost set is the number of students who were accepted into the summer workshop each year. The middle set is the number of students who attended at least once. The rightmost set is the number of students who finished the workshop, with an attendance rate of 75% or higher. The bars in graphs (c) and (d) are grouped into three different sets. The leftmost set shows the percentage of accepted students who attended the workshop at least once. The middle set shows the percentage of accepted students who finished the workshop. The rightmost set shows the percentage of students who attended at least once who finished the workshop.

Analysis of Recruitment Data. We can tell several things from these data:

[4] Based on grades and high school attendance record.

[5] Almost all applications received were accepted. The only exceptions were students who did not meet the age requirement (in high school). When College Now took over, there was the added constraint that students must be attending NYC public schools.

Table 2: Number of students at Bridges Summer Workshops (2006–2011)

	accepted		attended[a]		finished[b]	
	female	male	female	male	female	male
2006	44	23	21	14	17	9
2007	29	22	18	14	14	13
2008	27	51	16	36	12	30
2009	34	52	23	33	23	31
2010	35	24	27	23	24	19
2011	28	29	25	23	24	23

[a]Attended at least once

[b]Finished with overall attendance rate of at least 75%

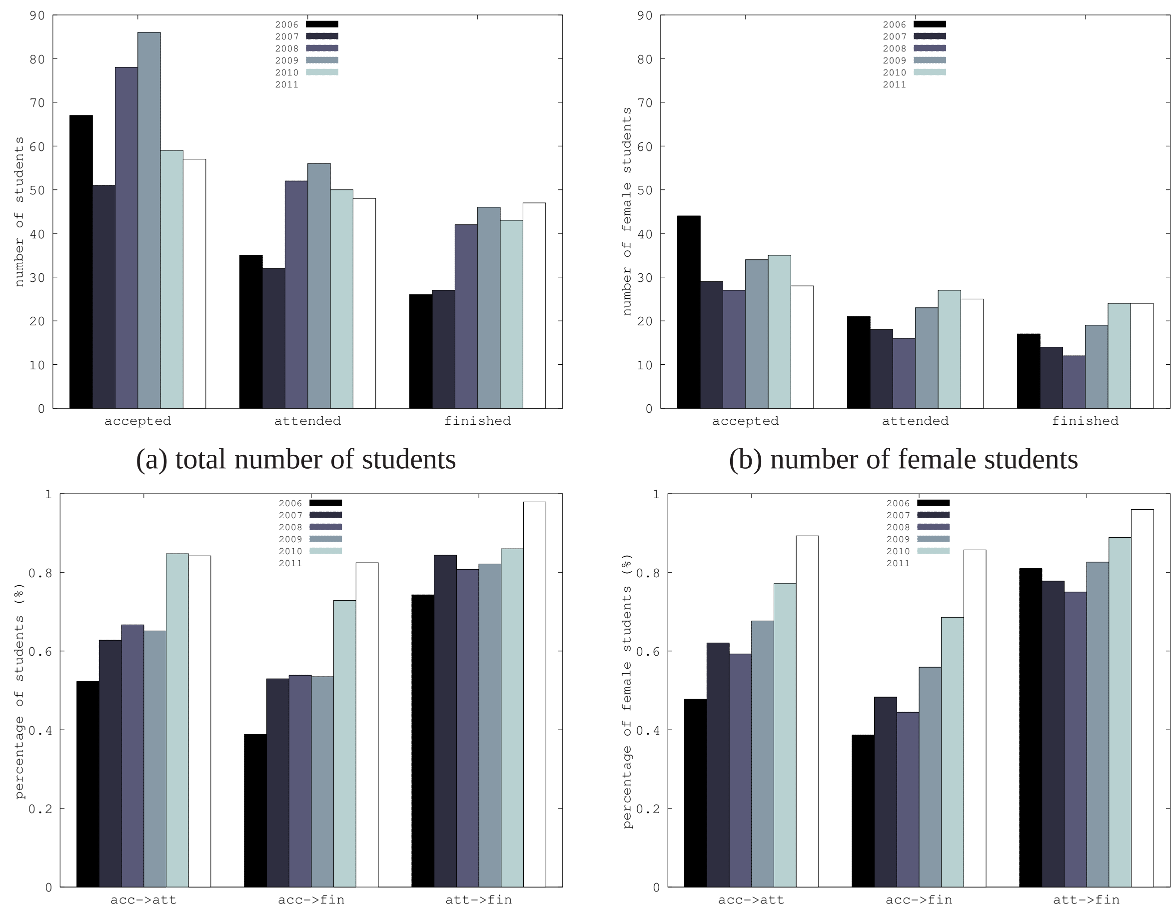
- *The third model of recruiting was much more reliable than the first two models in terms of retention rate.* While the second model (mass mailing) resulted in the largest numbers of students who applied and attended at least once, the third method (see Figure 1c, last two bars of middle set) was markedly better at recruiting applicants who finished the workshop. **78%** of students recruited using the third model (who were accepted) finished the workshop, versus 46% and 54%, respectively, with the first two recruiting methods. **92%** of students recruited using the third model who attended at least once finished the workshop, versus 79% and 81%, respectively, with the first two recruiting methods.

- *We were able to engage most students, and that the more experience we had with the program the better we got at engaging students.* The rightmost set of bars in Figure 1c show a gradual increase, from 74% of students finishing the workshop in the first year to 98% of students finishing the workshop in the sixth year.

- *The numbers of female students who attended were higher with the first and third recruiting methods, where personal contact was made with schools.* Even though the letter that went to principals (when the mass-mailing recruitment method was used) included specific language about the program being targeted to female and minority students, recruitment of female students was more successful when in-person contact was made with schools.

Table 3 shows the number of schools that sent students to the Bridges Summer Workshop each year. In total, the Bridges Summer Workshops have received students from 70 high schools across New York City. Students have come mostly from Brooklyn; a few from Lower Manhattan schools, and one from the Bronx (which is a 2-hour subway journey, each way, to and from the Brooklyn College campus). Midwood High School, which is located next to Brooklyn College, is responsible for the largest group of attendees (21% over all 6 years; 55 students). Edward R. Murrow High School, which is located about a mile from Brooklyn College, is responsible for the second largest group of attendees from a single school (9% over all 6 years; 24 students). The third largest cohort came from It Takes A Village Academy (8% over all 6 years; 21 students).

No schools sent students all six years. Three schools sent students for 5 out of 6 years: Midwood, Murrow and Brooklyn College Academy (located on the Brooklyn College campus). One school, Brooklyn International High School, which is located several miles away, sent students 4 out of 6 years. Some schools have proven to be unreliable because applicants from those schools never attend. College Now has made use of our data in their recruiting, by targeting schools that reliably send applicants who attend the workshop.



(a) total number of students (b) number of female students

(c) percentage of all students (d) percentage of female students

Figure 1: Students who were accepted to, attended (at least once) and finished (minimum 75% attendance rate) the Bridges Workshops (2006–2011).

Figure 2 shows the grade level of participants in the summer workshops. In the first summer, admission was restricted to students entering their junior or senior years. In subsequent summers, admission was opened up to all high school students. While juniors and seniors represent the largest proportion of each cohort, a measurable number of freshmen and sophomores have attended successfully. The College Now recruiting is targeted to students entering their sophomore and junior years, which explains the proportion in 2010. The restriction in 2006 was because we were concerned about socialization aspects of a wide range of student ages. *However, this fear proved unfounded, as students in later summers interacted well with each other regardless of age—another important lesson learned.*

Figure 3 contains two figures that illustrate the ethnic diversity of the students who either applied to or attended the Bridges Summer Workshops. Note that these data were not collected consistently. On the Bridges Summer Workshop application for the first 4 years, students were asked about where their parents were born. The College Now application (used in 2010 and 2011) asks where the students were born, not their parents—which explains the disproportionate percentage of students who identify USA as their country of origin. In the last year (2011), students were also asked to specify their ethnicity on the application. In

Table 3: Number of schools sending students to the Bridges Summer Workshops (2006–2011)

	number of schools
2006	8
2007	22
2008	19
2009	35
2010	20
2011	15

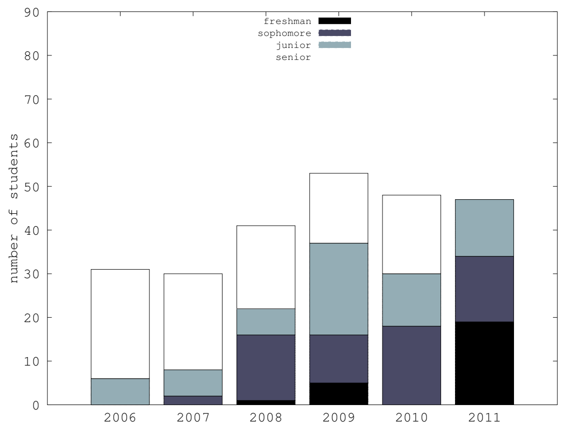


Figure 2: Grade-level of students who attended (at least once) the Bridges Workshops (2006–2011).

some years, students were asked to report their ethnicity on a survey given at the beginning of the workshop. For years in which ethnicity was not explicitly asked, the data is interpolated based on the proportional population statistics in Brooklyn[6].

2.4 Dissemination

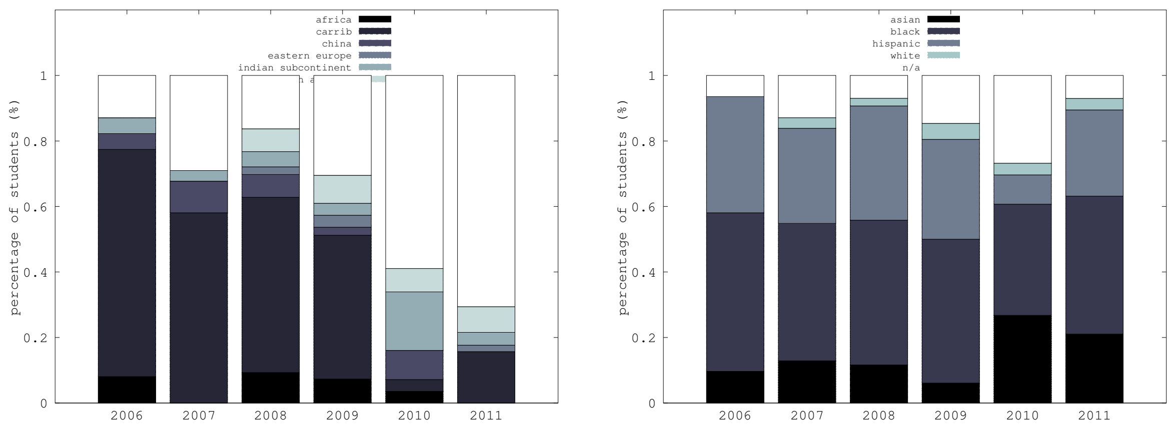
Project results related to high school activities have been disseminated in three ways: (a) indirectly, via the project web site; (b) directly, at workshops with classroom teachers; and (c) directly, at "showcases" for parents.

Web site. The project web site is: `http://bridges.brooklyn.cuny.edu`. On this site, there is a link to *instructional materials*, which is where all the curricular modules for high school classrooms can be found. (Note that undergraduate curricular modules are also available there.)

In addition, a combined booklet containing these modules, in the format of *Exploring Computer Science* [3], is also under preparation and will be linked on our project web site.

Teacher Workshops. The high school curricular materials developed through the Bridges program have

[6]The "Asian" category sums students from China and from the Indian subcontinent. Students from the Caribbean were equally divided into "Black" and "Hispanic" categories.



(a) country of origin

(b) ethnicity

Figure 3: Ethnicity of students who applied or attended the Bridges Summer Workshops (2006–2011).

been presented to classroom teachers in two workshops. In Summer 2009, in conjunction with the Bridges Summer Workshop (for high school students), we held a 4-day Teacher Enrichment in Computer Science (TECS) workshop. TECS is a component of the Association for Computing Machinery (ACM) Computer Science Teachers Association (CSTA) through which universities can advertise workshops for classroom teachers. Our TECS workshop was attended by 8 classroom teachers. Each day was split into two sessions, and one curricular module (see Section 2.1) was covered per session. Each session was divided into lecture and lab time. In the lab time, the teachers experienced the "Taster" session materials that students went through during their first week in the Bridges Summer Workshop. Since the TECS workshop was held in conjunction with the Bridges Summer Workshop, we also took teachers to observe the high school students in action. This helped the teachers see how the activities work in a classroom. Feedback from the teachers on our TECS workshop was extremely positive.

Many teachers who came (and others who did not attend) were interested in obtaining Professional Development (PD) credit for workshop participation. We found that, in order to offer PD credit, we would need to work with the NYC Department of Education. Initial investigation into such arrangements proved to be slow and bureaucratic, showing that a significant effort in future, with a lot of lead time, would need to expended in order to be able to offer such credit (at least the first time around).

In Summer 2011, we gave a presentation at the CSTA's CS&IT workshop entitled *When Robots aren't for Everyone—A Smorgasbord of Exploratory Computing Experiences* [5]. This presentation emphasized the diversity of curricular modules we have created and discussed the topics other than robotics and games. Feedback was positive.

Showcases. There are two types of regular "Showcase" events that have helped to share Bridges activities with the community.

The first is part of regular College Open Houses in which demonstrations and exhibitions are offered that highlight campus activities, educational initiatives and student projects to prospective students and their parents. Bridges to Computing is now well-known on campus, and the Admissions office and college administration regularly ask for demonstrations of Bridges educational activities at each Open House. Parents and prospective students have frequently made comments about the exciting activities: “when can I take that class?”

The second is part of the Summer Workshop. On the evening before the last day of the workshop, parents and families are invited to campus. Students set up posters and demonstrations to show off their projects to attendees. Light refreshments are offered (coffee/tea and cookies). For the students, this event is the culmination of the in-depth project they have chosen for their “Pick” sessions. Having a deadline where they know they will be exhibiting their work in a public venue helps keep the students focused during the workshop. These Showcases have been tremendously successful. Students delighted in showing parents their work. Parents have always offered extremely positive feedback.




2.5 Institutionalization and Sustainability

As indicated above, the high school courses have been institutionalized as part of the CUNY College Now program. Starting in Summer 2009, an informal collaboration was established with College Now, an existing partnership between CUNY and the New York City public school system. This collaboration was formalized in Summer 2010, when College Now took over the funding of the Bridges high school courses. Through College Now, students who pass the Bridges high school courses (either the *Does it Compute?* Summer Workshop or the academic-year *Computing Prep* class) receive one high school science elective credit. Starting in Fall 2009, and every term since then, the *Computing Prep* class has been administered by College Now and staffed by a Bridges instructor. Approximately 25 NYC public high school students completed the course each year. The course was offered in both Fall and Spring, with only students who successfully complete the Fall course being allowed to enroll in the Spring course (over 90% of students complete the course).

Starting in Spring 2011, through this partnership, an undergraduate course is being offered to high school students: *Introduction to Multimedia Computing* (described in Section 3). This course is funded by College Now and students who complete the course successfully earn 3 college credits through Brooklyn College.

In summary, the high school components of Bridges have been successfully institutionalized through a collaboration with the Brooklyn College chapter of the CUNY College Now program.

2.6 Evaluation

Evaluation of the high school component of the Bridges project was conducted by the project’s external evaluator, Dr Susan Lowes, Institute for Learning Technologies, Teachers College, Columbia University. The project had funding for evaluation for the original funding period (2006–2008). At the end of each year, Dr Lowes prepared an evaluation report. The conclusions of each report are shared below. (Note that the Summer Workshop is referred to as an “Institute” in these reports, which was the name of the program initially. We changed the name partway through the project, because we thought it would help attract more students and sound more fun.)

Evaluation was conducted using pre and post surveys administered to all students. The pre-survey was incorporated into the program application for the Summer Workshops, so there are more pre-surveys than post-surveys. Note that data was collected after 2008, but has not been analyzed. The number of surveys collected are listed in Table 4.

The full reports (for summers 2006, 2007 and 2008) are available from the PI (Sklar) upon request.

Bridges Summer Workshop 2006 Evaluation Report: Conclusions. Overall, the institute should be considered a great success. Although the students complained about the repetitive food, the lack of the promised Metrocard[7], and the movies, these were peripheral and logistical issues and do not seem to have affected their overall enjoyment of the actual workshops. The format—one week of overview and one week of work in a single area—seems to have worked well. The main issue is the matter of expectations: the fact that this was a better experience than many had expected suggests that they were expecting a traditional summer school format rather than a computer camp. In addition, the students seem to want to focus on areas that they believe have real-life applications (E-Biz, Graphics, Cryptography), suggesting that they need to understand the ultimate purpose—in terms of computer science or employment—of each workshop subject.

Bridges Summer Workshop 2007 Evaluation Report: Conclusions and Recommendations. Overall, the 2007 Bridges Summer Institute was more successful than the 2006 institute. This was due primarily to the reorganized schedule, which hit a good balance between giving a broad view of computer science through the "Taster" sessions and also having some depth in the "Pick" sessions. Although a greater effort needs to be made to get a higher rate of return on the final surveys so that we can report with more assurance that the surveys are representative of the entire population of students, it nevertheless seems clear that most of the students really enjoyed the experience and learned a great deal from it. There are very few recommendations and they are mostly minor changes:

- The gap between the number of applicants who are accepted and the number who arrive may be the result of unclear expectations on the part of the applicants. This year, students volunteered to recruit for next summer and the ambassadors (who related well to the students) could be used as well. However, this needs to be carefully organized in terms of scheduling, supplying materials, finding out the right classes to visit, etc.—and a staff person needs to be designated to take the lead on this.
- The Taster and Picks sessions that worked best engaged the students in a variety of hands-on activities. This is difficult for the Taster sessions, which are very short, but needs to be reinforced next year.
- There seem to have been two groups of students, which made teaching a challenge. The students in the larger group were there because they wanted to be. Many of them would have welcomed a greater challenge and would have liked more depth in the sessions they attended. Although it is difficult in these institutes, where the students come from different academic backgrounds and have a wide range of skills, it does seem from their comments that some of these students could have done more if they had been given the opportunity to do so. The students in the second (smaller) group seem to have been there as a result of parental pressure and were less interested in taking advantage of the opportunity. Clarifying the goals of the institute during the recruitment process may help weed out some of these

[7] Ticket for NYC public transportation

students. If not, the project should consider asking the most disaffected among them not to return after the Taster sessions.

- Although we did not ask about the non-Taster-session activities in the survey, the improvisation (social activity) session that all the students participated in seems to have been a success and to have given students an opportunity to get to know students not in their Pick or Taster sessions. At least one more activity that drew together students across groups might be added.
- The students clearly came out of the institute with a sense of the wide variety that is contemporary computer science. What is less clear is if they came out with a sense of the commonalities—the threads that run through all the sessions that makes this a science, not simply a web design or graphics program. They also liked hearing from the "professors" and some wanted more "teaching." This suggests that a few short lectures on computer science, possibly during lunch hour, might be appreciated and might help them pull the various strands together.

Bridges Summer Workshop 2008 Evaluation Report: Conclusions and Recommendations. Overall, the 2008 Bridges Summer Institute was the most successful yet. Despite complaints about being bored during the "Taster" Sessions, the students enjoyed the "Pick" sessions and felt they had learned something useful from them. Equally important, the students clearly came out of the institute with a better sense of the wide variety that is contemporary computer science, and with a more nuanced view of the qualities that make a successful computer scientist.

Table 4: High School Surveys

year	*term*	*type*	*number*
2006	Summer	Application	45
2006	Summer	Taster Feedback	26
2006	Summer	Post-Survey	31
2006	Fall	Application	36
2007	Spring	Post-Survey	6
2007	Summer	Application	51
2007	Summer	Taster Feedback	26
2007	Summer	Post-Survey	22
2007	Fall	Application	2 (new, in addition to Summer)
2008	Spring	Post-Survey	5
2008	Summer	Application	74
2008	Summer	Taster Feedback	45
2008	Summer	Post-Survey	39
2008	Fall	Application	16
2009	Summer	Application	81
2009	Summer	Taster Feedback	49
2009	Summer	Post-Survey	47
2009	Fall	Application	25
2010	Spring	Application	16
2010	Summer	Application	45
2010	Summer	Taster Feedback	41
2010	Summer	Post-Survey	39

Notes:
The Pre-Survey is integrated into each “Application”.
The “Taster Feedback” was anonymous, and given after the first week of each Summer Workshop.
The Pre-Survey (Application) and Post-Survey were not anonymous.

3 Undergraduate Activities

Since Fall 2006, the Bridges team has addressed the needs of undergraduate students at Brooklyn College in several ways. This section describes each of the following aspects of the project's undergraduate curricular activities:

- Development of CS Curricula (for both Non-CS Majors and CS Majors)
- Lessons Learned
- Dissemination
- Institutionalization and Sustainability
- Evaluation

3.1 Development of CS Curricula

The original Bridges proposal outlined five *flavors* for contextualized introductory computing which would be applied to traditional introductory programming courses for intended CS majors (*CS1* and *CS2*), to traditional introductory computer science courses for non-CS majors (*CS0*), and to new, non-traditional interdisciplinary introductory computer science courses for non-CS majors. The overall aim was to provide a gentle introduction to the field in a variety of ways, with the hope that intended majors, enrolling in sections of *CS1* and *CS2* would be retained, and that non-majors, enrolling in sections of *CS0* or interdisciplinary courses, would be intrigued and consider selecting or changing their major to computer science.

The five flavors were chosen to appeal to the Brooklyn College student body, as well as take advantage of the research and teaching interests and experiences of the original faculty members of the Bridges team. Three of the flavors were application areas in which computing is used: *Business*, *Medicine*, and *Law*. Two of the flavors combined technology-based areas: *Graphics and multimedia*, and *Robotics and simulation*. The content of the Graphics and multimedia flavor was gradually replaced by *Games*. The plan was to develop five flavored versions of each of the three traditional courses (*CS0*, *CS1* and *CS2*), as well as several non-traditional interdisciplinary courses. The result was 15 flavors of traditional courses, each offered twice during the project funding period, and 3 new non-traditional courses (*Everyday Technology To Go*, *Exploring Robotics*, and *Introduction to Multimedia Computing*), the first of which was offered once and the latter two have been offered multiple times.

Note that 6 of the courses discussed (all flavors of *CS0* and one interdisciplinary course) are part of the Brooklyn College "Core Curriculum", which is a set of 11 courses required by all undergraduates. These are divided into "Lower" and "Upper" Tiers, where the Lower Tier contains 9 courses that essentially fulfill the type of distribution requirement common in liberal arts programs. Of these 9 courses, students select one either computer science or math course. All flavored versions of *CS0* can be taken to fulfill the Lower-Tier requirement in computer science/math. It is expected that students will complete the Lower-Tier courses in their first two years. If students take a gateway course in a major subject (e.g., *CS1*), then they do not have to take the Lower-Tier course in that subject area. In addition to the Lower Tier, students are required to select two Upper-Tier courses. Here they have more choice. These courses are intended to be interdisciplinary and should be taken after students have selected their major. The non-traditional interdisciplinary course *Exploring Robotics* can be taken to fulfill the Upper-Tier requirement in the sciences.

Also note that the apparent success of any of the courses relied heavily on the instructor, which is a common phenomenon found when trying to assess curricular change interventions. There was not enough time or funding to conduct “control” versions of each flavored section with the same instructor. Evaluation must be compared in aggregate across flavored vs all non-flavored versions. In 2009, a survey was prepared by the project evaluator (Dr Susan Lowes) and administered to those faculty who taught Bridges sections of all courses (including the original five PI/Co-PIs and several graduate student adjunct faculty members). Comments below about the changes injected by faculty in the teaching of traditional courses are based on the results obtained through this survey.

The most successful of the courses developed under the Bridges project—CS1/Robotics, CS1/Games, Exploring Robotics, and Introduction to Multimedia Computing—have been sustained beyond the funding period.

Traditional Curricula for CS Majors (CS1 and CS2). Five flavored versions of both *CS1* and *CS2* were developed and offered:

- *Introduction to Programming in C++ (CS1)*
  The *CS1* course has many sections (10 or more) offered each term and is designed to introduce students to computer programming in C++. Topics covered include: software development lifecycle, program input and output, primitive data types, compound data types, variables, control structures, functions, basic algorithms, and classes. The *CS1* course is coordinated by a faculty member in the Computer and Information Science (CIS) department, and has a common final exam across all sections. This standardization limited the amount of modification that Bridges faculty members could inject in the flavored versions of the courses, i.e., a wholly new course could not be designed. Depending on the Bridges faculty member who developed the flavored version, the differences from the traditional offering of this course varied. Those instructors who made the most changes created lectures and labs built around examples within the flavored context. For example, all homework assignments in the robotics section described a simulated robot, and some hands-on labs involved working with physical robots in the classroom.

- *Advanced Programming in C++ (CS2)*
  The *CS2* course also has multiple sections (4 or more) offered each term and covers advanced programming in C++. The *CS2* course is more loosely coordinated. A common syllabus is shared and includes the following topics: object-oriented programming, pointers, arrays, recursion, and templates. As above, the amount of change injected in the Bridges flavors depended heavily on the instructor. Some instructors (e.g., robotics, graphics, medical applications) built lectures and labs around the flavored context. Others made minimal changes.

Traditional Curricula for Non-CS Majors (CS0). Five flavored versions of the Computer Science Lower Tier core class (i.e., *CS0*) were offered. This course has many sections (over 20) offered each term and is designed to introduce students to a broad range of topics in computer science, from Javascript to the halting problem. As with *CS1*, the course is coordinated by a faculty member in the CIS department, and has a common final exam across all sections. This standardization limited the amount of modification that Bridges faculty members could inject in the flavored versions of the courses, i.e., a wholly new course could not be designed. Depending on the Bridges faculty member who developed the flavored version, the differences from the traditional offering of this course varied. Some instructors (e.g., robotics, graphics, medical

applications) replaced all the hands-on labs (Javascript) with appropriate substitutions (e.g., robotics programming using RoboLab or graphics using Processing or biomedical simulations using NetLogo), and got permission to adapt the language-specific questions on the standardized final exam accordingly. Other instructors made no changes to hands-on components, and only mentioned the flavored applications in lectures. The curriculum for these courses is available online at:
`http://bridges.brooklyn.cuny.edu/curric.html`

Non-traditional Curricula for Non-CS Majors. Three non-traditional interdisciplinary courses were developed and offered as part of the Bridges project:

- *Everyday Technology To Go*
  This was a seminar course offered to students enrolled in the Macaulay Honors College, a selective CUNY undergraduate program. The class explored the role of automated (i.e., programmable) devices and state-of-the-art technology in society today. Broadly speaking this includes cell phones, ipods, personal organizers and portable games—all the types of gadgets that people carry around with them. Students explored how these devices have changed the way we communicate with each other, and how people organize and use their time. The course included a hands-on laboratory in which students invent tasks and design interfaces for handheld devices. The intention is that this special seminar will be a prototype for another Upper Tier core course (like Exploring Robotics); however, resources (materials and faculty) are not currently available for offering more sections of the course. The curriculum is available online at:
  `http://agents.sci.brooklyn.cuny.edu/scp50/`

- *Exploring Robotics*
  This course has become extremely popular. Even though students cannot take the course until the latter half of their degree, we have anecdotal evidence that this course has convinced some students to minor in computing or pursue a masters degree in computing. *A follow-up study should be conducted to see if quantitative data substantiates this anecdotal evidence for any significant number of students*. The curriculum is available online at:
  `http://agents.sci.brooklyn.cuny.edu/corc3303/`

- *Introduction to Multimedia Computing*
  This course provides a broad introduction to a range of topics in multimedia computing including: multimedia hardware and software, human interface design and input using multi-media devices, graphical and other forms of output to multi-media devices, computer-based sound editing, agent-based programming for simulations and robotics, and uses of multi-media in industry. Emphasis is on the design and creation of artifacts. The curriculum is available online at:
  `http://www.sci.brooklyn.cuny.edu/~sklar/teaching/f09/cis3.5/`
  `http://www.sci.brooklyn.cuny.edu/~meyer/CISC1600/index.htm`

3.2 Lessons Learned

Note that we ended up merging the three application areas into one flavor called "applications", after each had been offered at least once. This was due to several reasons. First, we found through survey data that students did not enroll in a particular section because of its flavor, but instead because of their own scheduling constraints or preference for (or against) particular faculty members. Second, instructors felt that it would be more beneficial and reach more students if they were given the opportunity to use examples from all three application areas, instead of being restricted to just one. Third, shifts in personnel meant that we did not have enough Bridges faculty to cover all the flavored sections. Of the five original PI's, only three remained in the CIS department for the last 2 years of the extended project timeline (one went to another college and one went to a different department within Brooklyn College).

3.3 Dissemination

Project results related to undergraduate activities have been disseminated via the project web site, which is: `http://bridges.brooklyn.cuny.edu`. On this site, there is a link to *instructional materials*, which contains links to all the undergraduate courses that took place under the auspices of the Bridges project.

3.4 Institutionalization and Sustainability

There are several aspects of the undergraduate components that have been institutionalized. The two courses in *Exploring Robotics* and *Introduction to Multimedia Computing* are regular parts of the computer science course offerings, and both are well supported by the College. As an Upper Tier core course, Exploring Robotics has access to funding to support course needs. Through this fund, a large inventory of rechargeable batteries and chargers has been purchased in order to maintain a green energy source for the $100+$ robots that are used for the course (requiring 6 AA batteries each). The College also has funding in the form of a Student Technology Fee (STF), for which faculty can apply to cover a variety of technology costs. Since the inception of the Bridges project, multiple STF proposals have been granted to purchase laptops and robots for hands-on lab work. A recent STF proposal will refurbish the department's Multimedia Computing lab, which will help strengthen the Introduction to Multimedia Computing course. In addition, the College administration has just renovated a classroom as a dedicated robotics lab for teaching *Exploring Robotics* and sections of *CS1* that use robotics.

3.5 Evaluation

Evaluation of the undergraduate component of the Bridges project was intended to be conducted in two ways. The first way was to look at the enrollment statistics and determine if our original goals had been met: to increase the retention and throughput of female and minority (Black and Hispanic) students via Bridges sections of early courses. The second way was through pre and post surveys.

Enrollment Data.

The following series of charts and tables attempt to capture the effects that students' experiences in flavored Bridges classes had on subsequent course experiences. We analyzed the following:

- Continuing from CS0 to CS1 (Tables 5 and 6)
- Continuing from CS1 to CS2 (Tables 7 and 8)
- Continuing from CS1 (eventually) to CS3 (Tables 9 and 10)
- Continuing from CS2 to CS3 (Tables 11 and 12)

We say *continued* when we mean that a student took the subsequent course (e.g., continued on to take CS1 after taking CS0) in a later semester.

Each table has a row for each flavor of Bridges class and an aggregate row labeled "none" that averages over all non-flavored sections. In each case, we look at multiple statistics, aggregated over 10 semesters (Fall and Spring, from Fall 2006 through Spring 2011[8]). The data are shown both graphically, in charts, and as numbers in tables. The labels shown below in parenthesis (e.g., *(...)*) are the abbreviations used in the tables. The labels shown below in square brackets (e.g., `[...]`) are the abbreviations used on the charts. Because we are interested in measuring the effects on female and underrepresented (Black and Hispanic) students, the tables are broken down into comparisons by gender and by ethnicity.

The data values in the "broken down by gender" tables are:

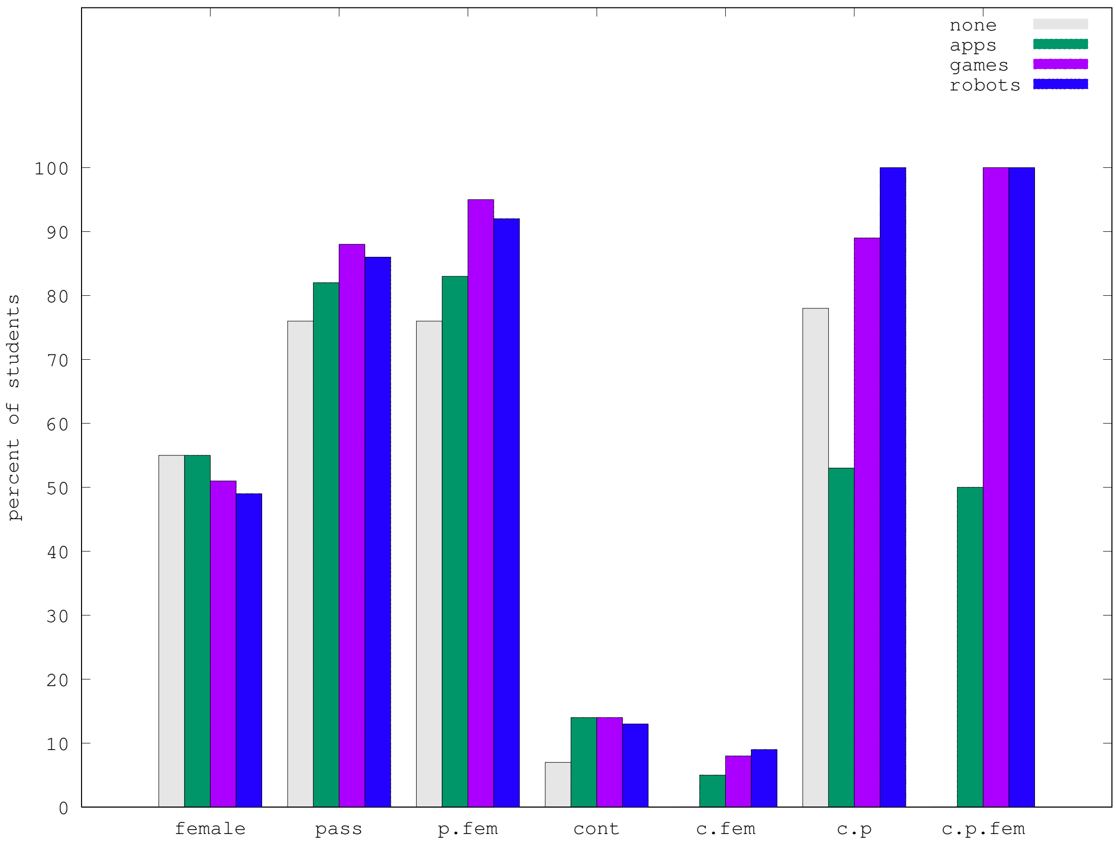
- the average total enrollment *(enrollment avg num)*
- the percentage of female students enrolled *(enrollment % of fem)* `[female]`
- the percentage of all students who passed *(passing % of all)* `[pass]`
- the percentage of female students who passed *(passing % of fem)* `[p.fem]`
- the percentage of all students who continued *(continuing % of all)* `[cont]`
- the percentage of female students who continued *(continuing % of fem)* `[c.fem]`
- the percentage of all students who continued and passed *(continuing & passing % of all)* `[c.p]`
- the percentage of female students who continued and passed *(continuing & passing % of fem)* `[c.p.fem]`

The data values in the "broken down by ethnicity" tables are:

- the average total enrollment *(enrollment avg num)*
- the percentage of Black students enrolled *(enrollment % of blk)* `[blk]`
- the percentage of Hispanic students enrolled *(enrollment % of hsp)* `[hsp]`
- the percentage of all students who passed *(passing % of all)* `[pass]`
- the percentage of Black students who passed *(passing % of blk)* `[p.blk]`
- the percentage of Hispanic students who passed *(passing % of hsp)* `[p.hsp]`
- the percentage of all students who continued *(continuing % of all)* `[cont]`
- the percentage of Black students who continued *(continuing % of blk)* `[c.blk]`
- the percentage of Hispanic students who continued *(continuing % of hsp)* `[c.hsp]`
- the percentage of all students who continued and passed *(continuing & passing % of all)* `[c.p]`
- the percentage of Black students who continued and passed *(continuing & passing % of blk)* `[c.p.blk]`
- the percentage of Hispanic students who continued and passed *(continuing & passing % of hsp)* `[c.p.hsp]`

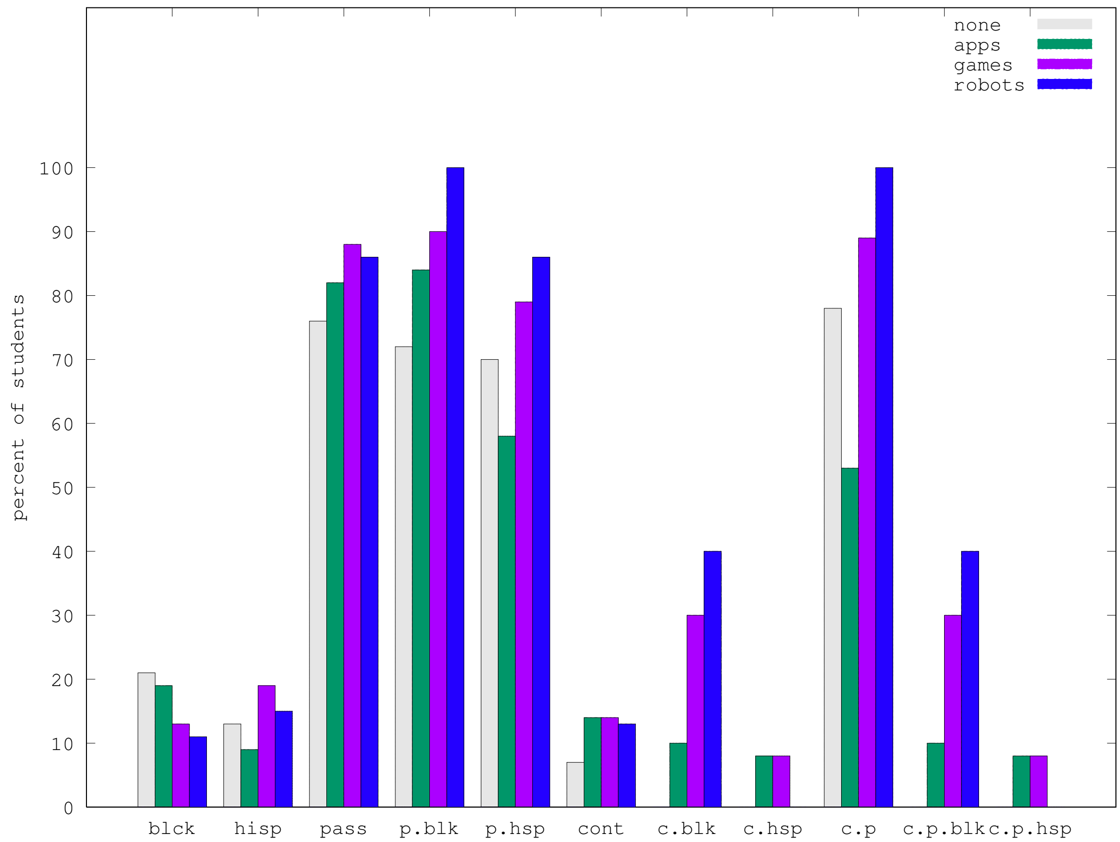
[8] Summer and Winter intersessions were not included.

Table 5: Continuing from CS0 to CS1, broken down by gender



	enrollment		passing		continuing		continuing & passing	
	avg num	% of fem	% of all	% of fem	% of all	% of fem	% of all	% of fem
none	19	55%	76%	76%	7%	0%	78%	0%
apps	13	**55%**	**82%**	**83%**	**14%**	**5%**	53%	**50%**
games	16	51%	**88%**	**95%**	**14%**	**8%**	**89%**	**100%**
robots	16	49%	**86%**	**92%**	**13%**	**9%**	**100%**	**100%**
explor	19	48%	**93%**	**89%**	4%	0%	29%	0%
mmedia	25	40%	**87%**	**92%**	**10%**	**5%**	60%	**50%**

Table 6: Continuing from CS0 to CS1, broken down by ethnicity

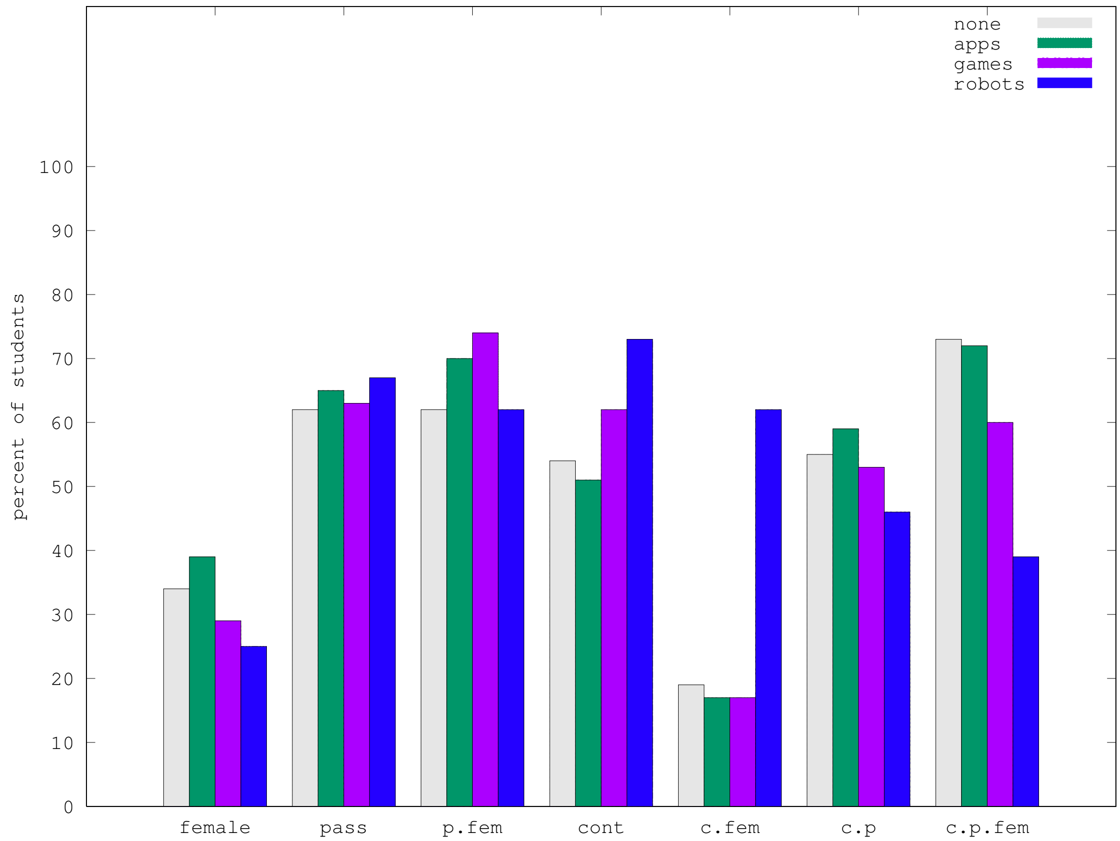


	enrollment			passing			continuing			continuing & passing		
	avg num	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp
none	19	21%	13%	76%	72%	70%	7%	0%	0%	78%	0%	0%
apps	13	19%	9%	**82%**	**84%**	58%	**14%**	**10%**	**8%**	53%	**10%**	**8%**
games	16	13%	19%	**88%**	**90%**	**79%**	**14%**	**30%**	**8%**	**89%**	**30%**	**8%**
robots	16	11%	15%	**86%**	**100%**	**86%**	**13%**	**40%**	0%	**100%**	**40%**	0%
explor	19	20%	10%	**93%**	**84%**	**90%**	4%	**3%**	0%	29%	0%	0%
mmedia	25	16%	8%	**87%**	64%	**89%**	**10%**	**22%**	0%	60%	**11%**	0%

We make the following observations about the effects of CS0 (refer to Tables 5 and 6):

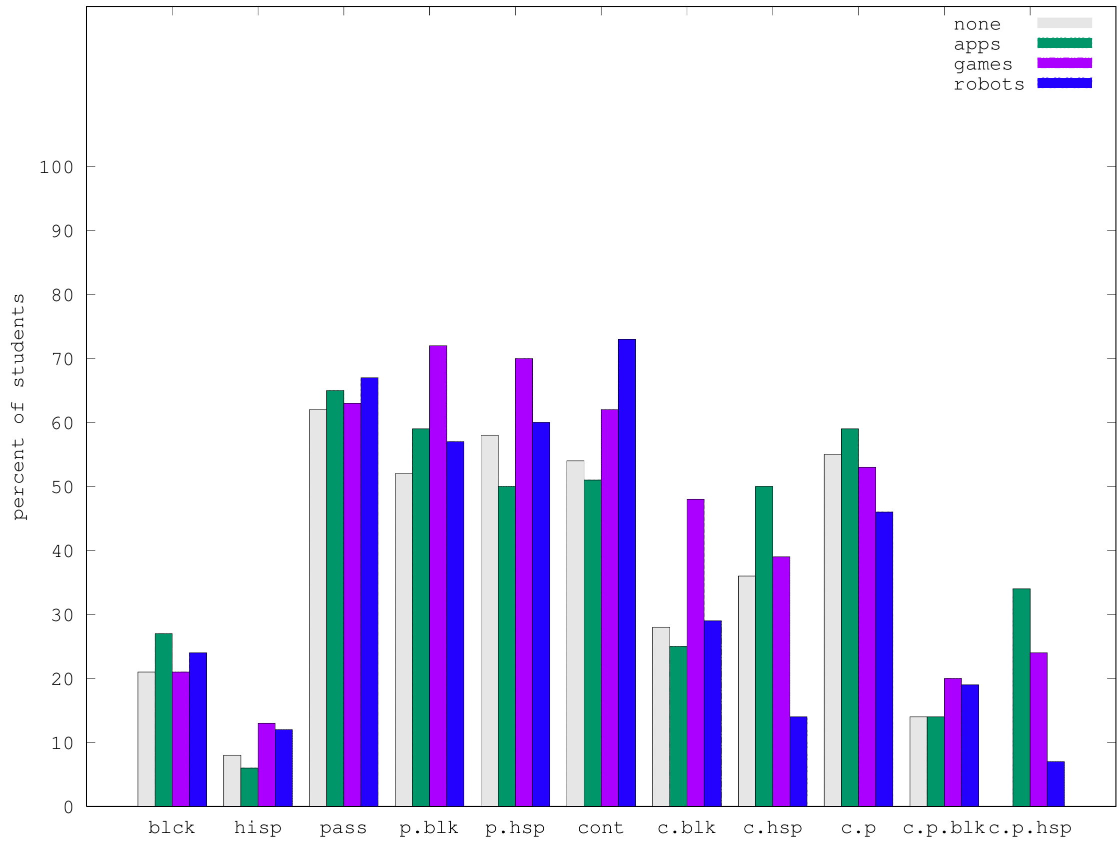
- A higher percentage of students from all demographic categories enrolled in flavored sections of CS0 passed, versus those enrolled in non-flavored sections. This also includes the two interdisciplinary courses: Exploring Robotics and Introduction to Multimedia Computing.
- A higher percentage of students from all demographic categories enrolled in flavored sections of CS0 continued on, versus those enrolled in non-flavored sections.
  This includes Introduction to Multimedia Computing, but not Exploring Robotics. In the latter case, it is notable that the Exploring Robotics course is part of the college's upper-tier core, as described early; and as such, is typically taken by students who are juniors or seniors and have already chosen their major. Computer Science students who had taken CS1 prior to taking this course would not be counted in our statistics here (since we are measuring the influence of a course on students' subsequent actions). We should also note that the Introduction to Multimedia Computing is not a prerequisite for CS1, so many students took it concurrently with or after taking CS1, in which case they would not be counted here.
- A higher percentage of students from all demographic categories enrolled in flavored sections of CS0 continued on and passed the subsequent course (CS1), versus those enrolled in non-flavored sections of CS0, with the following exceptions: female and Black students enrolled in Exploring Robotics, and Hispanic students enrolled in the robotics flavor of CS0, in Exploring Robotics, or in Introduction to Multimedia Computing.
- It is interesting to note the high percentage of female students enrolled in all sections of CS0, Exploring Robotics and Introduction to Multimedia Computing: 49.6% on average. All of these courses are electives. *Even in the cases of the lower-tier CS0 and upper-tier Exploring Robotics, where a large percentage of students who enroll are not declared (or intended) Computer Science majors, the rate of female enrollment is quite high.*

Table 7: Continuing from CS1 to CS2, broken down by gender



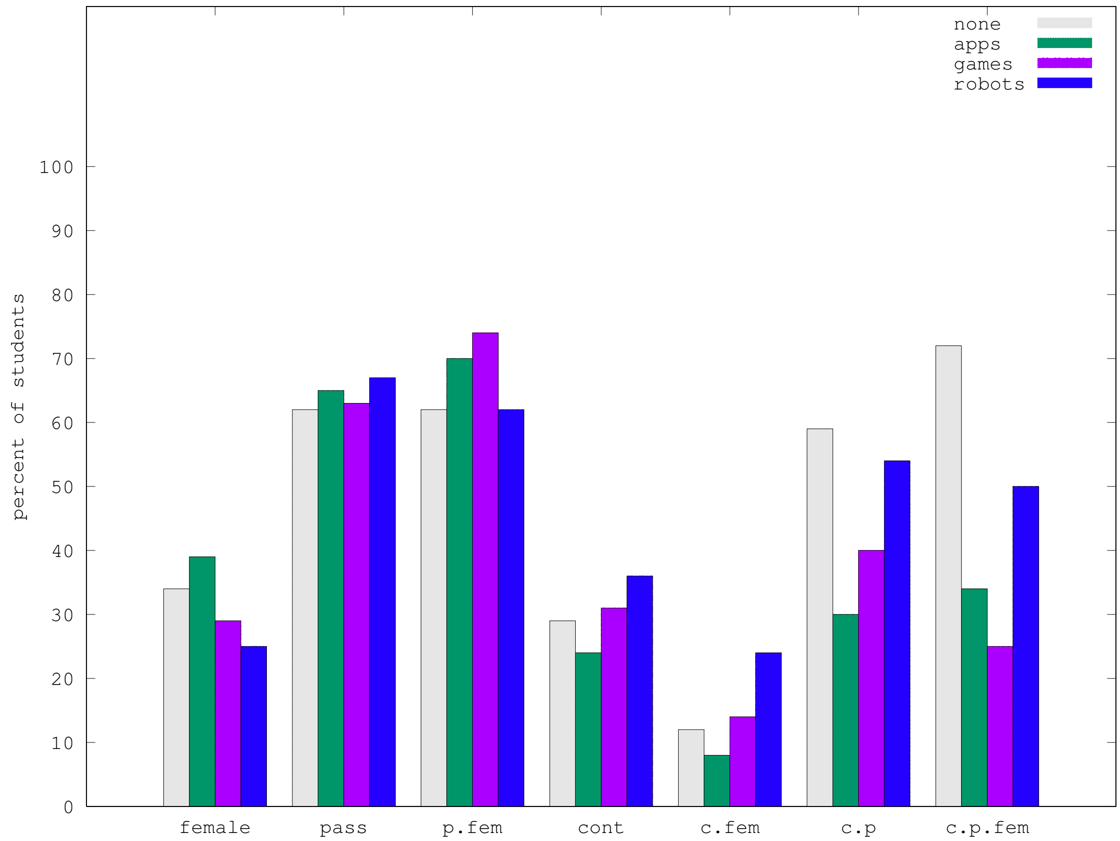
	enrollment		passing		continuing		continuing & passing	
	avg num	% of fem	% of all	% of fem	% of all	% of fem	% of all	% of fem
none	18	34%	62%	62%	54%	19%	55%	73%
apps	19	**39%**	**65%**	**70%**	51%	17%	**59%**	72%
games	26	29%	**63%**	**74%**	**62%**	17%	53%	60%
robots	20	25%	**67%**	**62%**	**73%**	**62%**	46%	39%

Table 8: Continuing from CS1 to CS2, broken down by ethnicity



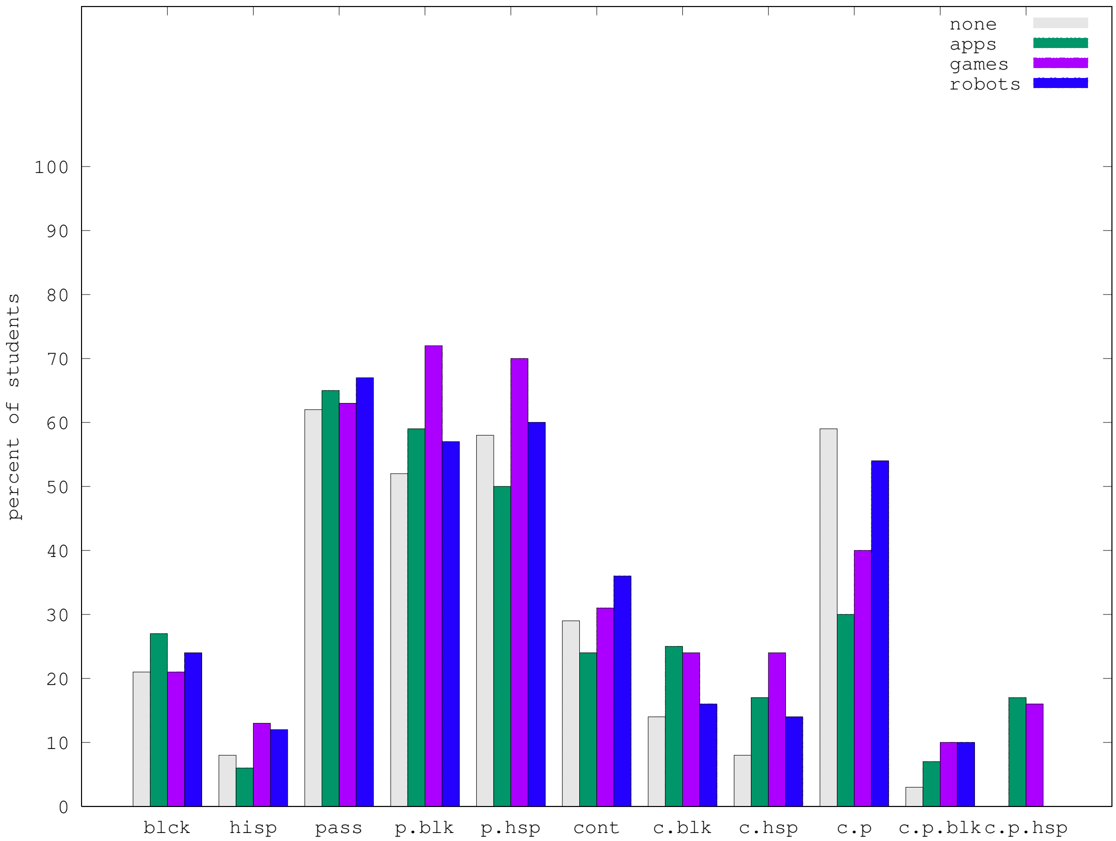
	enrollment			passing			continuing			continuing & passing		
	avg num	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp
none	18	21%	8%	62%	52%	58%	54%	28%	36%	55%	14%	0%
apps	19	**27%**	6%	**65%**	**59%**	50%	51%	25%	**50%**	**59%**	**14%**	**34%**
games	26	21%	**13%**	**63%**	**72%**	**70%**	**62%**	**48%**	**39%**	53%	**20%**	**24%**
robots	20	**24%**	**12%**	**67%**	**57%**	**60%**	**73%**	**29%**	14%	46%	**19%**	**7%**

Table 9: Continuing from CS1 (eventually) to CS3, broken down by gender



	enrollment		passing		continuing		continuing & passing	
	avg num	% of fem	% of all	% of fem	% of all	% of fem	% of all	% of fem
none	18	34%	62%	62%	29%	12%	59%	72%
apps	19	**39%**	**65%**	**70%**	24%	8%	30%	34%
games	26	29%	**63%**	**74%**	**31%**	**14%**	40%	25%
robots	20	25%	**67%**	**62%**	**36%**	**24%**	54%	50%

Table 10: Continuing from CS1 (eventually) to CS3, broken down by ethnicity

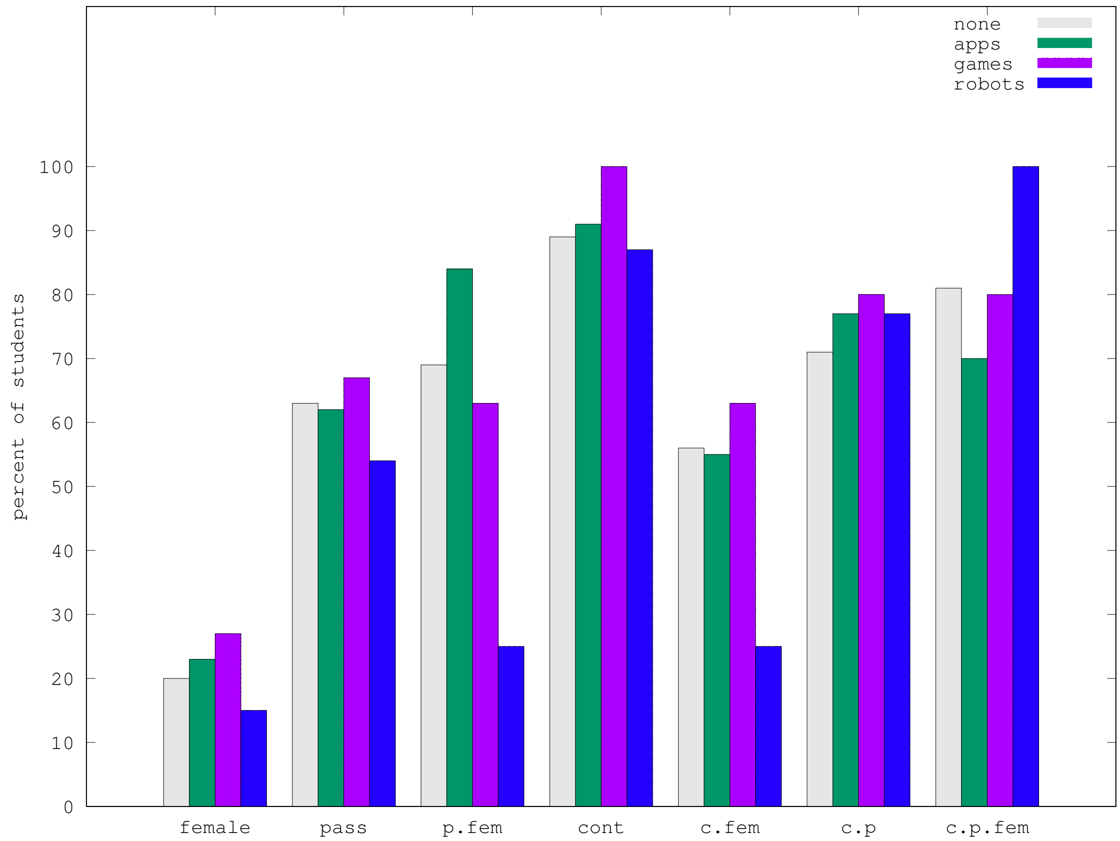


	enrollment			passing			continuing			continuing & passing		
	avg num	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp
none	18	21%	8%	62%	52%	58%	29%	14%	8%	59%	3%	0%
apps	19	**27%**	6%	**65%**	**59%**	50%	24%	**25%**	**17%**	30%	**7%**	**17%**
games	26	**21%**	**13%**	**63%**	**72%**	**70%**	**31%**	**24%**	**24%**	40%	**10%**	**16%**
robots	20	**24%**	**12%**	**67%**	**57%**	**60%**	**36%**	**16%**	**14%**	54%	**10%**	0%

We make the following observations about the effects of CS1 (refer to Tables 7, 8, 9, and 10):

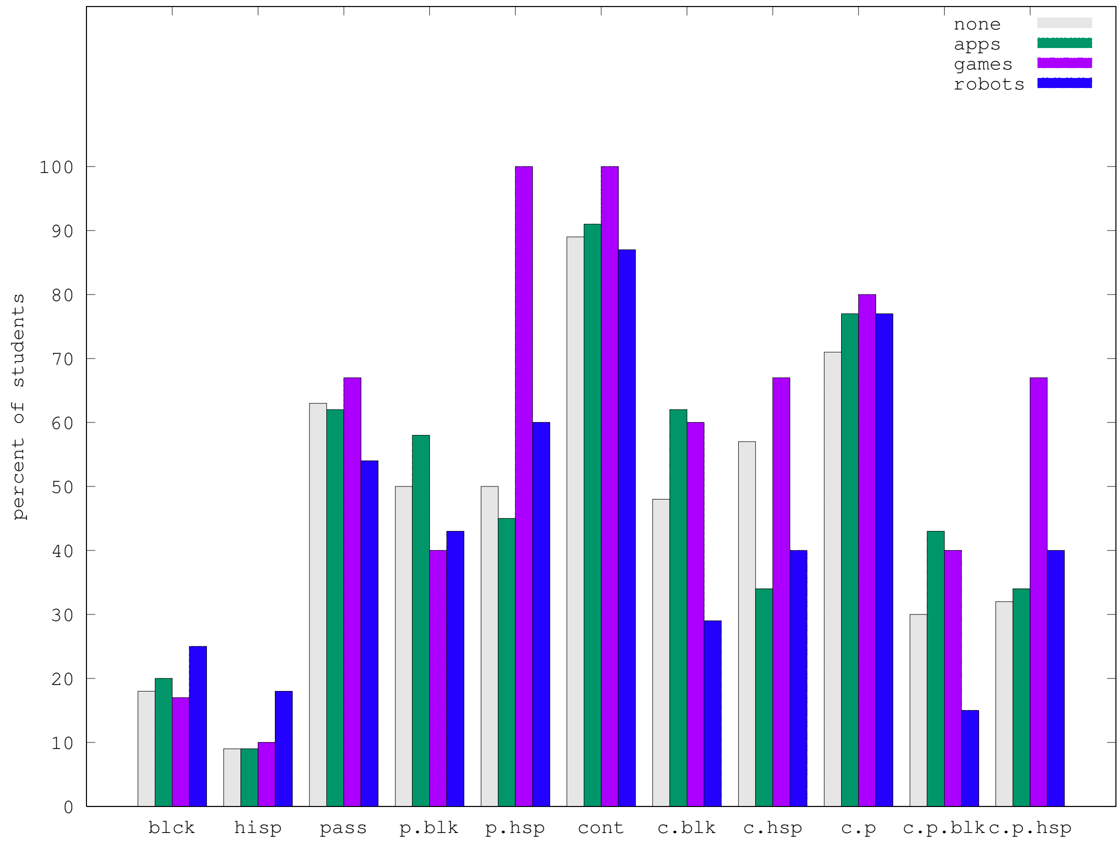
- A higher percentage of students from all demographic categories enrolled in flavored sections of CS1 passed, versus non-flavored sections, with one exception: Hispanic students in the apps flavor (50% passing rate versus 58% in non-flavored sections).
- A higher percentage of all students enrolled in flavored sections of CS1 continued on, as well as some underrepresented students, versus those enrolled in non-flavored sections. The notable underrepresented groups are: female students enrolled in the robotics flavor of CS1, Black students in games and robotics flavors of CS1, and Hispanic students in apps and games flavors of CS1.
- A higher percentage of all students taking the apps flavor of CS1 continued on and passed the subsequent course (CS2), versus students from non-flavored sections. This includes both Black and Hispanic students, and a close match for female students (72% for apps versus 73% for non-flavored).
- The rates for female students continuing from games or robotics flavors of CS1 on to CS3 are higher than from non-flavored sections (14% and 24%, respectively, versus 12%). However, the passing rates for these students in CS3 are not as good (25% and 50%, respectively, versus 72%).
- The rates for Black and Hispanic students continuing on from flavored versions of CS1 and passing CS3 are higher in all categories, except for Hispanic students who took a robotics flavor of CS1.

Table 11: Continuing from CS2 to CS3, broken down by gender



	enrollment		passing		continuing		continuing & passing	
	avg num	% of fem	% of all	% of fem	% of all	% of fem	% of all	% of fem
none	20	20%	63%	69%	89%	56%	71%	81%
apps	18	**23%**	62%	**84%**	**91%**	55%	**77%**	70%
games	15	**27%**	**67%**	63%	**100%**	**63%**	**80%**	80%
robots	14	15%	54%	25%	87%	25%	**77%**	**100%**

Table 12: Continuing from CS2 to CS3, broken down by ethnicity



	enrollment			passing			continuing			continuing & passing		
	avg num	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp	% of all	% of blk	% of hsp
none	20	18%	9%	63%	50%	50%	89%	48%	57%	71%	30%	32%
apps	18	**20%**	**9%**	62%	**58%**	45%	**91%**	**62%**	34%	**77%**	**43%**	**34%**
games	15	17%	**10%**	**67%**	40%	**100%**	**100%**	**60%**	**67%**	**80%**	**40%**	**67%**
robots	14	**25%**	**18%**	54%	43%	**60%**	87%	29%	40%	**77%**	15%	**40%**

We make the following observations about the effects of CS2 (refer to Tables 11 and 12):

- The percentage of female students who passed apps sections of CS2 is higher than for non-flavored sections. The passing rates for the other flavors are lower, especially robotics.
- The percentage of students in all categories who continued on from CS2 to CS3 is higher for flavored sections versus non-flavored sections, with the close exception of robotics (87% versus 89% from non-flavored sections of CS2).
- The percentage of female students who took a games flavor of CS2 and continued on to CS3 is higher than for any other sections.
- The percentage of students in all demographic groups who continued from CS2 on and passed CS3 is higher, with three exceptions: female students who took apps CS2 (passing rate of 70% versus 81% from non-flavored sections), female students who took games CS2 (passing rate of 80%, which is very close to 81%), and Black students who took robotics CS2 (passing rate of 15% versus 30%).

Finally, one general comment. Although the data was collected over 10 semesters and the total number of students accounted for is statistically significant, in most cases there are measures for only 2 sections of flavored courses at each level and the numbers of students from individual underrepresented groups is small. So it is difficult to draw any significant conclusions from these data.

We believe the these data need to be analyzed in conjunction with the survey data, described below, in order to try and determine the causes for the increases seen in passing rates and continuation rates.

Survey Data.

During the first three years of the project, we administered and collected pre and post surveys from all undergraduate Bridges sections of the courses described here, as well as a sampling of "non-Bridges" courses. Dr Lowes helped design the surveys, but was not funded to analyze the results. The surveys were anonymized, with a code to match pre and post surveys to individuals. The survey data has all been entered into an electronic database. Unfortunately, however, due to the lack of resources allocated to evaluation in the original project, these surveys have not been analyzed. Table 13 lists the instruments and numbers of surveys that have been collected. If additional funding is found, then an evaluator could analyze these data.

Table 13: Undergraduate Surveys

year	*term*	*type*	*number*
2006	Fall	Undergraduate Post-Survey	52
2006	Fall	Undergraduate Pre-Survey	114
2007	Spring	Undergraduate Post-Survey	228
2007	Spring	Undergraduate Pre-Survey	284
2007	Fall	Undergraduate Post-Survey	276
2007	Fall	Undergraduate Pre-Survey	379
2008	Spring	Undergraduate Post-Survey	253
2008	Spring	Undergraduate Pre-Survey	345
2008	Fall	Undergraduate Post-Survey	340
2008	Fall	Undergraduate Pre-Survey	443
2009	Spring	Undergraduate Post-Survey	397
2009	Spring	Undergraduate Pre-Survey	550

4 Mentoring and Community-Building Activities

Mentoring activities have been part of the Bridges project in three ways: (1) undergraduates mentoring high school students, (2) undergraduate peer mentoring, and (3) faculty mentoring undergraduate students. Each activity is described below.

4.1 Undergraduates mentoring high school students

Thirty-two advanced undergraduate computing students have worked as **Student Ambassadors** on the project, since Summer 2006. Statistics on the demographics of the Student Ambassadors is shown in Table 14. Most students who applied were accepted, so the demographic distribution is more a result of the recruiting process rather than the application selection process. Recruiting was done by circulating an advertisement (paper flyer and email) to students enrolled in advanced CIS classes, and through word-of-mouth (from faculty and other ambassadors, after the first year).

There have been anywhere from 3–10 student Ambassadors employed at any one time. The Ambassadors have staffed the Summer Workshops, fulfilling teaching assistant roles in the classroom and mentoring roles outside the classroom. During the academic year, they have worked as peer-tutors in the Bridges to Computing Resource Center. They have also worked on research with Bridges faculty members, both during the summer and the academic year.

Table 14: Undergraduate Student Ambassadors

total number	*% female*	*% Black*	*% Hispanic*
32	59%	34%	9%

We collected informal data which shows that the Ambassadors who were computing majors when they became Ambassadors (except for one student, all the Ambassadors have been computing majors or double-majors) remained computing majors after their term as an Ambassador was over. Several Ambassadors went on to graduate school after finishing their undergraduate degrees.

After Summer 2007, the Ambassadors were surveyed by the project evaluator. Following is a quote from one of the Ambassadors remarking on the experience of mentoring high school students: "I learned that there really are no 'bad' children in the world—open yourself up to them, give them free food and fun and opportunity, and all (well, most) of the attitude will melt away. I learned how productive just 8 days can be, and how much the ambassadors can really bridge the gap between students and professors."

4.2 Undergraduate peer mentoring

Undergraduate peer mentoring is facilitated through a **Peer Tutoring** activity. Starting in Fall 2007, the CIS department designated a room for peer tutoring, originally called the "Bridges to Computing Resource Center" and now called the "CIS Help Room". This room was originally staffed by Bridges Student Ambassadors, offering walk-in tutoring to introductory computing students. The room was open for 8–10 hours per week. In Spring 2010, the tutors comprised not only Bridges Ambassadors but also a large number of advanced computer science majors who must complete a service-learning component of a required independent project course. In Fall 2010, with no more funding left for Bridges Ambassadors, the "help room" has

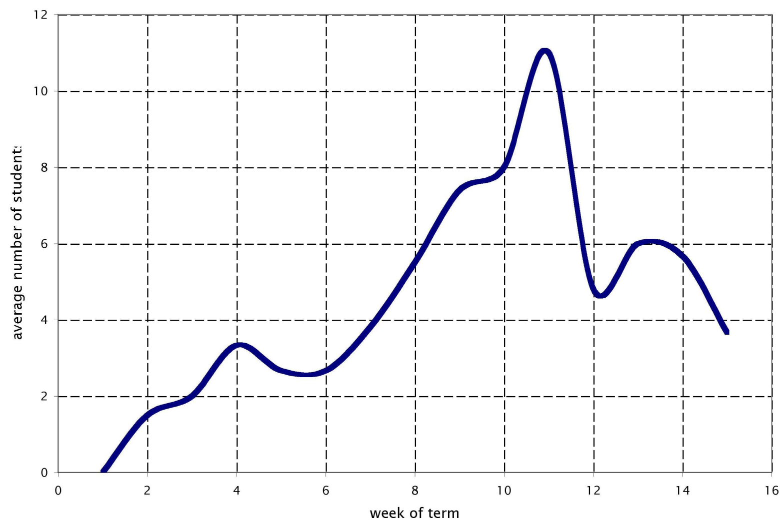


Figure 4: Usage statistics for the Bridges to Computing Resource Center

solely been staffed by advanced computer science majors. The room is open for tutoring almost 50 hours per week, starting at 9am and extending some evenings to 9pm. Equipment in the room is maintained by the department's lab technician. Scheduling is primarily overseen by the faculty member in charge of the service-learning course (someone not involved in the Bridges project).

Figure 4 illustrates the usage of the Bridges Resource Center, averaged over 5 semesters (Fall 2007 through Fall 2009[9]). The points on the curves show the number of students who visited the help room, over time, normalized to "week per term". Clearly, activity in the "help room" peaks around week 11 and then declines toward the end of the term. Note that week 11 is typically the point in the schedule by which students have to withdraw from a course, which accounts for the peak.

4.3 Faculty mentoring of undergraduate students

Faculty mentoring of undergraduates is facilitated through the Bridges in two ways: first, by establishing an informal time for social interaction called *Tea with Professors*, and second, by supervising undergraduate research projects.

Tea with Professors

The *Tea with Professors* events occurred 2-3 times per term during the initial three years of the project, and has continued though not as frequently. Each Tea has a theme. Most of the Teas are informal. Some include a panel, a talk or a showcase activity. Students enrolled in any CIS class are invited to attend. The first Teas were held in Spring 2006. Attendance averaged 10-20 students per Tea. Many students became regulars, and other students' attendance varied depending on the theme. Themes have covered topics such as careers in computing, applying to (and what to expect in) graduate school, and summer internships. A number of invited speakers, from other departments at Brooklyn College and from other universities, also

[9] Data was tallied through Fall 2009. The peer-tutoring activity continues, though attendance data is not regularly tallied.

gave talks. All the Teas are listed in Table 15.

Figure 5 shows the popularity of topics over all the Tea with Professor events, illustrated by plotting the average attendance according to topic. The events involving CIS department faculty sharing their research, and potentially recruiting students for research projects, has had the greatest level of attendance. Close behind in popularity are the events where outside visitors have come and talked about their research or company. The least popular Teas have been those in which we have advertised an open "town meeting" style event where we invited students to provide feedback on aspects of the CIS department.

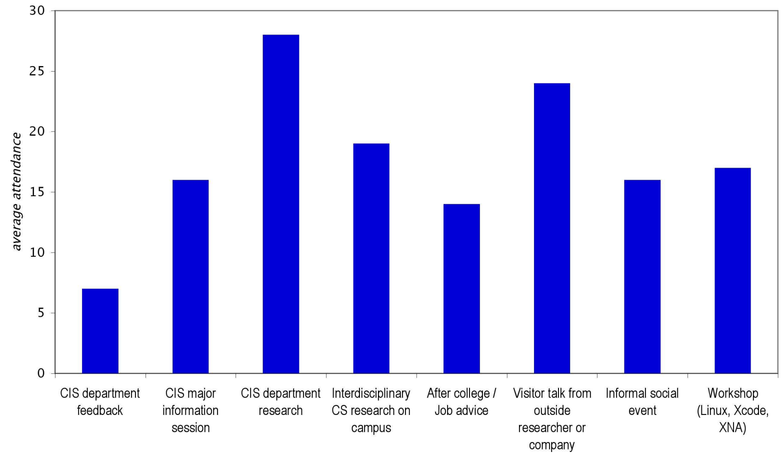


Figure 5: Tea with Professors attendance

Undergraduate Research.

Over the course of the project, 32 undergraduate student Ambassadors were engaged as peer-mentors and research assistants. Most of the students had the opportunity to work on research with project faculty members. Some have received additional funding via REU Supplements for summer research. The projects students have worked on include: design and execution of experiments in electronic markets, design and implementation of data visualization software, research and design of robot interfaces, and database design and implementation for semantic web applications.

Table 15: Tea with Professors topics and dates

Spring 2006	
Bridges In Brooklyn	23-Feb-06
A better CIS department	23-Mar-06
Careers in Computer Science	27-Apr-06
Planning for Graduate School	25-May-06
Fall 2006	
Hobbies (what we do when we're not in front of the computer)	28-Sep-06
Student's opinion regarding a new curriculum	17-Oct-06
CIS Majors Info Session	2-Nov-06
Computer Start-up: Turingscraft	16-Nov-06
Robotics Showcase	12-Dec-06
Spring 2007	
How and Why to Major in Computer Science	27-Feb-07
Evening Tea with BPC Students	12-Mar-07
Summer Internships	22-Mar-07
Microsoft: Discussing Vista, Jobs at Microsoft, Games, and MSDN	12-Apr-07
Marjorie Skubic: Recognition Technology for Functional Assessment of Older Adults	3-May-07
Fall 2007	
Learn how to install Linux!	4-Oct-07
Bridges Reception	1-Nov-07
Microsoft: Gus Weber	6-Dec-07
Spring 2008	
Learn how to install Linux!	21-Feb-08
Marie desJardins: MultiAgent Communities	28-Feb-08
Career Panel: Industry Representatives	20-Mar-08
CIS Majors Info Session	17-Apr-08
Fall 2008	
Xcode Workshop	25-Sep-08
Putting the Science Back into Computer Information Science	23-Oct-08
Research Topics with Faculty	13-Nov-08
Why Apple, Inc in Higher Education	2-Dec-08
Spring 2009	
XNA Game Studio 3.0 Workshop	19-Feb-09
Two Talks on Computational Science	12-Mar-09
Life After Brooklyn College: Grad School and Jobs	1-Apr-09
CIS Research Topics	7-May-09
Fall 2009	
Thinking about Graduate School	27-Oct-09
Programming for the Performing Arts	3-Dec-09
Spring 2010	
Bridges to Computing Resource Center Open House	11-Mar-10
Google Panel	8-Apr-10

4.4 Community Outreach

The original proposal intended for outreach to the community to be a large part of the Bridges project. It was hoped that the Student Ambassadors would help shape this aspect of the project, based on their interests, abilities, background experience and contacts in the community. However, in practice, the only outreach activities have been instigated by the project faculty. Three such activities were pursued, with mixed success. Each reaches a different part of our community: (1) the larger Brooklyn business community, (2) the Brooklyn College community outside of the CIS department, and (3) the Brooklyn public schools.

In the first year, the local business community was reached via the Church Avenue Merchants Block Association Inc. (CAMBA), which is an organization of local businesses along one of the major small business districts in Brooklyn (Church Avenue). Two students were hired as interns for CAMBA, but this did not turn into a longterm relationship, primarily because CAMBA representatives were not responsive.

In the second year, two ambassadors worked on a database project for the Brooklyn College Office of Research. This proved to be a fruitful experience for all parties involved, giving practical, applied work experience to two ambassadors.

The most successful community outreach efforts were to local schools, through educational robotics activities and teacher training. A teacher workshop (described above) was held in Summer 2009. Educational robotics activities involved Ambassadors going to schools to help with after-school robotics programs in several Brooklyn middle and high schools. In addition, several Ambassadors assisted in the New York and New Jersey Regional RoboCupJunior event (`http://www.rcjnynj.org`), which was organized by the PI and brings middle and high school students together annually.

4.5 Institutionalization and Sustainability

The Bridges project has definitely changed the culture of the CIS department in three significant ways:

1. Bringing new and innovative teaching materials and methods to students;

2. Opening and maintaining the peer-tutoring center; and

3. Introducing and sustaining Tea with Professors activities.

These activities will not stop, even though the BPC funding is gone.

5 Follow-on Activities

Below is a list of follow-on activities that could be undertaken in the future:

- Investigate ways to reach out to other CUNY campuses (all of which have College Now programs) to extend our course offerings to other boroughs.
- Work with the NYC Dept of Education to obtain professional development credit for the teacher workshops (section 2) and offer these once per year.

- Analyze remaining high school survey data, collected after 2008.
- Analyze undergraduate survey data.
- Curricular materials for undergraduate courses have been collected onto the Bridges web site. However, the materials are not packaged for general use. One of the important lessons learned with this project is that we should have included a curriculum writer in the budget to oversee preparation of materials for dissemination to a wider audience.
- Publish a booklet of original materials for high school curricular modules. This is in progress.
- It might be useful to administer a follow-up survey to (former) high school students who attended Summer Workshops and Computing Preparatory classes starting in 2006.
- It might be useful to administer a follow-up survey to former Ambassadors and find out what they are doing.
- A survey was administered to Bridges faculty to determine how they have experienced the project and what they did to change their teaching as a result of the project. This data was collected but never fully analyzed and reported.
- A large number of pre and post surveys were administered to undergraduates who took Bridges and non-Bridges sections of CS0, CS1 and CS2. These data have been entered in a database and are waiting to be analyzed.
- The enrollment data analysis detailed in Section 3 should be correlated to the faculty survey results and the student pre and post surveys.

6 Summary

The following major results have been achieved by the project:

1. Two computing courses for high school students have been institutionalized as part of CUNY's College Now program. *Computing Prep* is a course offered each semester and also in the summer. NYC public high school students who complete the course receive one high school science elective credit. *Introduction to Multimedia Computing* (see below) is a course offered once a year and is open to NYC public high school students who have successfully completed the *Computing Prep* class. *Introduction to Multimedia Computing* is offered at the college level, for 3 credits.

2. The high school curricula developed by the project has been presented in workshops to the Computer Science Teachers Association (CSTA) community[5]. The material has been compiled into a booklet (formatted similarly to *Exploring Computer Science* [3]), for easy distribution. Eight teachers participated in this workshop.

3. *Flavored* versions of an introductory programming course for undergraduates have been developed and are offered at Brooklyn College each semester as the first course for students intending to major in any computing discipline (*Computer Science*, *Multimedia Computing*, *Information Systems*, and *Computational Math*). The two most successful "flavors" are *robotics* (average enrollment of 19 students per term) and *gaming* (average enrollment of 26 students per term).

4. An introductory-level interdisciplinary course for undergraduates called *Exploring Robotics* was developed and is offered at Brooklyn College each semester as an elective course that fulfills general education requirements; this course has no prerequisites and does not require any background in computing, programming, or robotics. This course is extremely popular, and the annual enrollment averages 212 students.

5. An introductory-level interdisciplinary course for undergraduates called *Introduction to Multimedia Computing* was developed and is offered at Brooklyn College each semester as the first course for students intending to major in *Multimedia Computing*. This course has no prerequisites and does not require any background in computing or programming. This course is also popular, and the annual enrollment averages 21 students. One section of this course is also offered to high school students through the CUNY College Now program (see above).

6. Undergraduate Ambassadors participate as teaching assistants in the CUNY College Now high school summer program. Originally, these students were funded through stipends as part of the Bridges budget. Now they are funded by College Now.

7. Undergraduate peer-tutoring within the Computer and Information Science (CIS) department at Brooklyn College has been given dedicated space, establishing the *Computing Resource Center*, where peer-tutoring is available $40+$ hours per week. Tutors are advanced undergraduate majors who participate to fulfill the service-learning component of an independent project degree requirement. On average, more than 60 students per term use this space for tutoring.

8. A recurring event called *Tea with Professors* was established within the CIS department to bring faculty and students together in an informal setting for discussing a wide range of topics, such as career options in computing and pathways to graduate school. Speakers from industry and research

institutions across the country have been invited to present their work and talk with students. More than 600 students have attended *Tea* events.

9. Project activities are showcased in the community through two types of events. As part of the College Now summer workshop for high school students, an evening Showcase event takes place in which parents and families are invited to view posters and demonstrations of student work. As part of regular Brooklyn College open houses, demonstrations are offered that exhibit interdisciplinary (robotics and multimedia/games) work of current students. More than 400 students have presented their work to parents and prospective students.

10. Successful experiences with faculty mentoring undergraduate research projects led to an academic year Research Experiences for Undergraduates (REU) Site project[10]. This grant is helping to sustain funded undergraduate research. To date, 27 students have received funding through this REU Site project.

11. Six conference and journal publications have been published describing various aspects of the project [5, 7, 10, 1, 8, 9].

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