Artbotics: Community-Based Collaborative Art and Technology Education

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Abstract

The paper describes the formation and the progress of the Artbotics collaboration between disciplines in art and computer science. Its focus is on the pedagogy and issues of interdisciplinary undergraduate course development, particularly how to define and maintain the balance between Art and Science education.

1 Introduction

It is often suggested that Art and Computer Science are the disciplines with the greatest potential for interdisciplinary research. From Bell Laboratories in the 1960s to the Advanced Telecommunications Research Institute International in Japan now, technology laboratories have invited artists to be part of their creative research [Sandin et al 2006]. Often centers and laboratories in higher-education institutions nourish the collaboration between Art and Computer Science by providing students and educators with non-traditional research labs and programs. The Electronic Visualizations Lab (EVL) at the University of Illinois at Chicago, the MIT Media Lab and the Center for Research in Electronic Arts and Technology (CREAT) at the University of California at Santa Barbara (USCB) are a few of many labs and centers established to promote such collaboration [Sandin 2006; Legrady 2006].

While many of those centers and labs focus on graduate education in electronic media arts and technology, programs geared toward undergraduate and K-12 students have also been developed. Stephenson et al. [2006] developed a two-year program to bring toether undergraduate Art, Design and Computer Science majors to engage in 3D graphics and new media research. The research concentrated especially on students who are underrepresented in Computer Science and who do not have an access to a research program. Using an interdisciplinary and problem-driven approach, the program's goal was to help students to be engaged in computing and research.

The marriage of Art and Computer Science in academia is often inevitable due to the needs of both disciplines nowadays. Universities and colleges have experienced a drop in enrollments in computing disciplines, and thus are in search of ways to broaden participation in computing. Flourishing new media art practices recently and the development of creative media and game industries make artists and the art discipline more than ready to seek out partners in science and technology. The interdisciplinarity is believed to be the key to creating greater synergy; allowing each to reach accomplishments beyond the goals directly set by each discipline.

Success in long-term interdisciplinary collaborations, however, depends on openness for mutual understanding and balanced goals for the collaborating partners. The collaborators must earn rewards not only in the field of the collaboration but also in their own respective academic or professional field [Sandin et al 2006].

In this paper, we introduce the pedagogy and the outcome of the most recent Artbotics course and examine the challenges in keeping the balance between Art and Computer Science in the interdisciplinary curriculum.

Figure 1: Students in the Artbotics course, brainstorming their project at the Revolving Museum in Lowell, MA

2 Overview of Artbotics program

In the summer of 2006, the Artbotics program started with a collaboration between professors in the Art and Computer Science departments at the University of Massachusetts Lowell (UML) and staff members at the Revolving Museum in downtown Lowell. The program is geared toward high school students in the community and undergraduate students in UML. We introduced art and computing to students through the development of interactive art projects using simplified sets of robotics technology for public exhibit. It was funded by the National Science Foundation as a part of their Broadening Participation in Computing program. The uniqueness of the

Artbotics program comes from its many layers of partnership and collaboration, creating a nexus of art, science, museum and community. The partnership has been organically maintained throughout three distinct programs that so far have been developed: a summer pilot program in the summer of 2006, a high school after school program in the fall of 2006, and a new undergraduate course offered at UML in the spring of 2007. Seven college students in Art and Computer Science joined the eight-week full-time summer pilot program. The eight-week long high school after school program accepted twelve high school students. Some of the college students from the summer pilot program remained as mentors for the high school students. Twenty-two students in a variety of majors, including Business Administration, English, History, Philosophy, Music, Social Science, Criminal Justice as well as Art and Computer Science, are currently enrolled in Artbotics, the new undergraduate general-education course at UML.

2.1 Project objectives and goals

The goals of our Artbotics program came from concerns and understanding of current conditions in the related disciplines and community. Some of them are:

- Too few diverse students in computing.
- Different learning patterns of diverse students not accommodated by computer science.
- Limited student understanding of the field of computing.
- Too few opportunities for public to view art that uses computing.
- Too few mentoring opportunities for prospective computing students.
- Infrastructure not in place to support attracting more students to Computer Science.

As a result, our goal is to (1) increase the participation of women and minorities in computing through the use of innovative and interactive technologies, (2) broaden student understanding of the field of computing, teaching them that computing can be a part of many disciplines and used in a variety of ways, (3) introduce computing to the public through art exhibitions of the projects, and (4) build community with mentoring opportunities for students.

Although the primary goal is very much about computing, it is important to maintain the quality of the art-making process and the resulting exhibit to accomplish our goal and to satisfy each party in the program: students, program leaders and the public.

2.2 Core knowledge and materials

The partnership between the three different parties from Computer Science, Art and the Revolving Museum made it possible to bring different types of core knowledge and learning experiences to students. For example, the professors from computer science provided students with instruction on how to program, how to use the Super Cricket, how to solder wires and handle electronic gadgets, how to use motors and sensors to make interactive kinetic projects, while the art professor brought more topics in aesthetics, new media art and process, and the relationship between form and content. In the meantime, museum staff shared the museum's mission in public-community based art and provided students with the opportunity to learn how to organize and implement the exhibits in a professional manner. A dedicated education staff in the museum closely worked with students in the actual construction of the projects, using hand or power tools and various art materials.

Students mainly used a variation of Handy Cricket, a microcontroller co-developed by Martin [Martin 2000], called the Super Cricket. The Handy Cricket enables students to implement interactivity by programming sensors and actuators using the Logo language, a text based programming language. Various types of sensors such as touch, infrared range, and light sensors were given to students along with actuators including DC motors, servo motors, light bulbs and LEDs.

2.3 Pedagogical Approach

On top of the interdisciplinary approach, our programs are team-based, project-based, and exhibit-driven. We use pair programming as well as the hybrid of systematic and bricolage design process approaches throughout the curricula developed under the program.

Students are encouraged to have a strong sense of a collaborative team from the very beginning of the program. For example, on the first day of the summer pilot project, we held a tape wrapping workshop in which faculty and students created tape-wrapped sculptures as teams of two or three.

In coordination with the Revolving Museum, the leaders in the program set the date for the exhibition of the project. One or two exhibits per program are planned and implemented in the curriculum as projects. We found the exhibit-driven approach make students much more motivated and productive through the journey of their project.

Interactive artworks using robotic technology demand a thoughtful design process from students. Knowing that students in our program may be people who learn better by trial and error rather than following a systematic design process, we encourage students to take the hybrid of both design processes from the systematic approach and the bricolage approach. We believe this way of starting projects can help them to constitute the initial proposal of their concept ahead of time, to embark on the actual implementation process in a timely manner, and to let the original plan evolve as the project progresses.

Studies show that pair-programming experience increases broaden participation in computing fields and helps debunk the myth that programmers work alone all the time [Williams 2006]. The approach provides students with a realistic view of how computing professionals are interacting with other colleagues. In this collaborative context, we hope to dispel the notion of the asocial programmer, and provide positive, realistic experiences in teamwork, design, and programming [Yanco et al 2007].

3 New undergraduate course curriculum

Our most recent curriculum development, the Artbotics undergraduate course, is quite different from the previous summer pilot and fall after school program. The course is co-taught by two CS professors, an Art professor and the museum's educational staff. The course was originally proposed as co-numbered, with General Education credits in technology given to arts students and arts credit given to science students. To qualify the criteria of both the Art/Humanities and Technology with Lab General Education requirements at UML, topics and goals were set in a way to fulfill the expected students' learning experiences in both General Education choices. This structure challenged the collaborating leaders to further investigate the necessary core knowledge for this non-traditional course. One of the big components of the course, other than the two disciplines' collaboration, was service learning. Service learning was adopted naturally into the class curriculum from our initial goal to build the community of mentoring opportunities for students. While the previous programs had learning and mentoring in a different program period, the new course was designed to have these two concurrently happening within the period of the program.

Through the current semester-long Artbotics course, we hope to allow students in a variety of majors to explore the intersection between Art and Computer Science, especially Robotics, through community-based public exhibitions and service learning experience. We expect students to learn founding principles in both the fields of Art and Computer Science in a more structured manner, and then to put them into practice by creating interactive, tangible exhibits that are displayed in public settings. The knowledge and experience gained during the class are expected to be further deepened by the service learning experience of mentoring high school students from the community in an after school program. The course includes guest lectures from practitioners in Art and Computer Science. The class meets twice a week for a seventy-five-minute long lectures and an eighty-minute long lab.

3.1 Topics

Hybrid topics occurring due to the interdisciplinary course design are introduced as well as discipline specific topics.

The hybrid core includes:

- Contemporary art practices of the collaboration with science and technology.
- Problem-solving process of engineering and art—its commonality and differences.
- Sustainable community through art, science and technology, and education.

The computer science and robotics core includes:

- Introduction to imperative programming: functions, arguments and return values.
- Introduction to real-time systems including sensors, actuators and control loops.
- Agent-based models of computing (sense-act loops).
- Elements of robotics systems and how to physically create them (e.g. wiring and construction techniques).
- Uses of computing in a variety of fields.

The art core includes:

- Examination of form and content: use of visual language to support communicative issues such as concept, content and subject matter; the interplay between media and idea.
- Traditional visual language, e.g. aesthetics in color, composition, value, texture and material.
- Histories and aesthetics of New Media Art.

3.2 Objectives

The objectives of the course are many, falling into three areas: those that are related to CS and Robotics, to Art and to service learning. The course objectives include the following:

CS and Robotics related objectives:

- Have hands-on experience with embedded computing and digital technology.
- Gained the ability to formulate structured algorithms and program them.
- Understand the use of sensors and interactive algorithms.
- Carry out a project that includes computing from inception to public exhibition.
- Understand how computing is used in a variety of fields and applications.

Art related objectives:

- Have examined principles of aesthetic and conceptual elements in visual art.
- Be able to find strategies for a successful and engaging art expression.
- Have investigated examples of art and technology collaboration especially in public domain.
- Evaluate interactive art works in various contexts, including gallery or public installation.

Service learning related objectives:

- Deepen the knowledge in the subject matter by teaching and mentoring high school students.
- Recognize art and science education as a way of supporting sustainable community.

3.3 Deliverables

Two public exhibits at the Revolving Museum were planed in conjunction with our course. One, called "Electrifying!: The Art of Light and Illumination," was held in early March, and the other is the show dedicated only to our students in the high school and college programs in the current Artbotics program, to be held in May. Deliverables are carefully designed to guide students to successfully fulfill their exhibit requirements as well as to understand core topics.

First of all, two interactive art projects are required for the public exhibits throughout semester. Students were encouraged to form a team and to employ the technologies and aesthetic concepts to create interactive work of art. In addition to the art projects, students are required to submit two papers related to artists practicing art and technology to understand current practices in the New Media Art scene, in order to contextualize their art making within the field, to get the inspiration for their project and to broaden the understanding about the possibilities of computing in creative field. Lab reports are written about the technical lessons that accompany labs outside the lecture. After each exhibit, we hold a class session to debrief the exhibit; after this session, the students turn in their reflection paper on the exhibit.

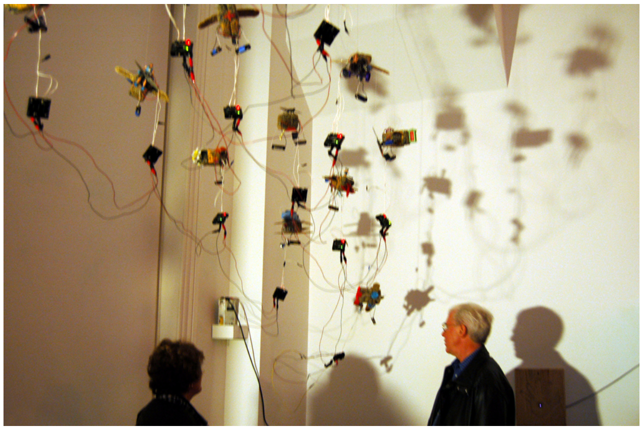

Figure 2: Chain Reaction with Beige Brigade

3.4 Exhibit: Electrifying Show

At the time of this writing, our students just finished their first project in conjunction with the show "Electrifying!: The Art of Light and Illumination" at the Revolving Museum opening on March 3, 2007. The show features a gallery exhibition, public artworks, and special events of dynamic light-art works created by over 100 youth and artists. The show's theme was inspired by the history of the Revolving Museum building (originally the Lowell Gas & Light Building built in 1859, the building once supplied the piped coal gas that lighted the mills, businesses, houses, and street lamps of the city). This location serves as a powerful metaphor as The Revolving Museum generates new creative energies and illuminates a diversity of artistic, educational, and community-focused functions [Revolving Museum 2006]. The Artbotics program's combined use of robotics technology and art was the perfect fit to the theme of the exhibition and made our projects central among other works in the exhibition. A total of twenty two students from the Artbotics class developed six unique interactive art pieces. Here, we present three of the projects for further discussion.

Chain Reaction with Beige Brigade

By Jay Critchley, Ian Boudreau and others

A group of students worked with established artist Jay Critchley who was invited to the exhibition with his work Beige Brigade, a collection of model airplanes combined with sand, found objects and instant cameras with their flashes. The artist's wish to work with students in the program met with some of the needs of students who wished to create a chain reaction interactive installation using electronic gadgets without taking too much time in construction. This made a very unique collaboration between the established artist and amateur artists/technologists.

In Chain Reaction with Beige Brigade (Figure 2), seventeen airplanes were hung from the ceiling of the gallery creating a loose arch shape. When a viewer approached the installation, the flash on the first camera was set off. This created a chain of firing the flash lights from the rest of cameras. Each plane had a Handy Cricket attached to it, which powered the two relays that set off the plane's two flashes. Each plane also had a light sensor pointed at the flash of the plane before it in the chain reaction. The aesthetic quality of the project was successfully achieved in its installation and enactment of interactivity through the physical space of the gallery, viewer and the artifact.

Nick ("whadyalookinat")

By Megan Reichlen, Chris Kirstein, Richard Wolff

Figure 3: Nick ("whadyalookinat")

Nick ("whadyalookinat"), shown in Figure 3, is a robot with a lightbulb, coffee can, metal wires, servo motors and 6 Sharp IR range sensors along with a Super Cricket. The rationale of the artists who designed the robot was to create a metallic robot with a unique persona who likes to watch viewers, but won't let the viewer to get too close to its personal space. Depending on the viewer's relative proximity to the robot, Nick blinks its light as if it is greeting the viewer. As the viewer moves closer, the light remains on. While the light is one, Nick turns its neck to follow the viewer who is nearby.

iBox

By Brian Legg, Ben Gemborys and others

iBox (Figure 4) was an interactive artwork that used light, touch and sound as a means to communicate the relationship between the sensitivity of a human eye to that of a robotic eye. It had the appearance of a robotic eye enveloped in a wooden box. It used two 180 degree servo motors, a relay, and a Super Cricket. The artists used an additional sound system that included a microphone and two speakers. When the viewer placed his or her hand over either one of hand-shaped sensor boards, the eyelid opened and turned to the side where the viewer was interacting. Both the eye ball and eye lid had 180 degrees of freedom to achieve more believable eye movement. Additional interactive elements came from the playing of a song, interpreted and programed into the Logo language, and a flash of light which made the eyelid blink as if it was surprised. Although the team proposed other kinetic elements originally, it was not possible to accomplish the entire plan within unpredictable process and timeline.

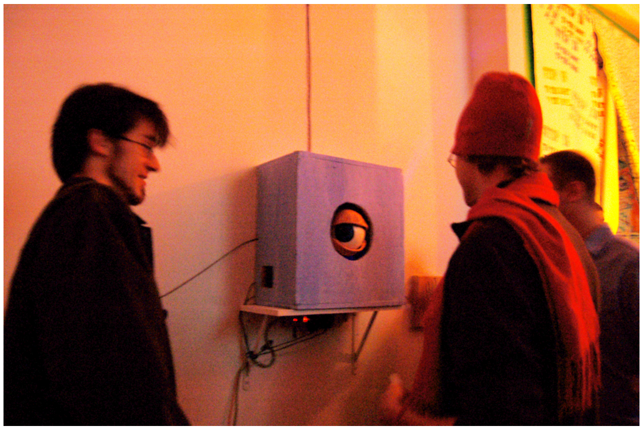

Figure 4: iBox installed at the Electrifying show

4 Challenges and Lessons

The first year of the Artbotics program has uncovered several challenges and taught us lessons, discussed in this section.

4.1 Balance between Art and Technology

Some of the questions constantly asked from the perspective of the art discipline include how to keep the integrity of art in the context of interdisciplinary collaboration when the program is funded from the Computer Science discipline and where is the proper balancing point between Art and Computer Science disciplines or whether the argument is necessary or not. On the contrary, the evaluation of the fall after school program shows surprisingly that students felt they had spent 90% of their time in art, with only 10% in technology. This result made the program leaders from Computer Science feel the need to further emphasize computing and programming. With more structured lectures and demonstrations, we hoped this would be achieved in the undergraduate Artbotics class.

Based on the reflection papers that student turned in after their first project and exhibit, this dynamic between Art and Computer Science seems different in the student's impression of their experience. When asked what proportion of time was devoted to art or technology, many felt they spent more in technology side rather than art side this time. However, it was clear that their understanding of what is art and what is technology is limited. Some students put only craft to the art side, while the rest of concept development, installation, programming and the use of electro-mechanism were put on the technology side. This might suggest what is more importantly to be paid attention to is the schism about art and technology, the perception that we all might have. By focusing on the intersection of both art and technology, it might be more valuable to introduce non-conventional art forms empowered by technology or the social and creative aspects of technology.

4.2 Balance between the quality of process and the end result

Because of the limited time given to students to create the project while they were first learning how to use the technology and apply the knowledge, many students in the Artbotics course expressed that the level of the course should be higher than a 100-level. Time pressure also sometimes creates a team dynamic in which students choose to do the tasks that they are best at doing, to maximize the effective process toward the finishing of their project. This, however, is not quite the intention of the project leaders, as we want to have as many students experience most aspects of both computing and art.

The balance of team dynamics could also be carefully considered when some of team members are professionals and college mentors while the rest are amateurs and high school students. We found that it is important to empower those team members with relatively beginning art or technology skills to feel that they are sharing the ownership of the project equally with the rest of team members to accomplish both the successful process and the engaging exhibit as a result.

4.3 Balance between the different expectations of professional museum and creative laboratory

We found that it is challenging to meet the expectations of a professional public exhibition when the outcome comes from the result of a creative laboratory with most students as beginning learners. To run their public space, the partners in the museum naturally expect professional maintenance of the exhibit, which sometimes requires much advanced engineering, beyond our program's intention. The problem is that not all of the students are ready to learn more advanced engineering tips to improve their work to make it more robust and easier to maintain. It is also problematic for professors to come up with technical solutions and teach them every time to students in need. To solve the problem partially, we found it is important to archive a technical database which contains the know-how and experience from the previous exhibits and to encourage students to explore more advance skills when students feel that it is necessary.

5 Conclusions

> *The combination of different strengths worked extremely well in this course's goals. Without a diverse pool of talent to draw from, not a single project would have succeeded.*
>
> *I feel that the artistic nature of our project was always the driving force in how I worked on the technological aspects of the project.*
>
> *It shows the power of art, and also the power of Robotics to take art to a new place. I think it's wonderful that these two things are brought together by students and myself.*

- From the reflection papers on the first exhibition in the Artbotics course 2007

Despite the challenges mentioned above, the development of the Artbotics curriculum has been successful. After the first exhibit, most of the college students in the Artbotics course felt that the program was very exciting and engaging. They shared this enthusiasm with Lowell High School students at a "Meet the Artists" event held at the museum just after school ended. As a result, the number of the applications of high school students to the Artbotics after school program was almost double the number of actual spots.

6 Acknowledgments

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