Physical Computing:
A Design Studio that Bridges Art, Science, and Engineering

Ken Camarata, Mark D Gross, Ellen Yi-Luen Do
Design Machine Group / Dept of Architecture / University of Washington
Box 355720, Seattle, WA 98195 USA
Tel: +1 206 543 1604
http://dmg.caup.washington.edu

Abstract: Design of computationally enhanced objects and places is an attractive and motivating activity that requires multidisciplinary learning and cooperation: it attracts computer scientists and engineers as well as architects, musicians, and artists. Students in our Physical Computing class explore this topic in a collaborative multidisciplinary environment. They learn to integrate design work in digital, analog, and mechanical domains involving sensors, software, and physical actuators as well as how to work together with team members from different disciplines.

Physical Computing

Our "physical computing" class, taught at the University of Washington's architecture department, brings students from a wide range of disciplines together into a collaborative studio learning environment. The studio is modeled after traditional architecture design studios (Schön, 1985; Shaffer, 1998) which teach an iterative design process informed by regular critiques. Students learn from one another and develop an understanding of each other's disciplines as they explore at the intersection of art, science, and engineering by designing and building computationally enhanced objects and spaces. Students from traditional design disciplines learn to do science (Kolodner, 1998) and engineering while science and engineering students gain design experience and learn to explore artistically.

"Physical computing" overlaps paradigms of ubiquitous, wearable, tangible, invisible, etc., computing—design that incorporates both material and computational media, employing mechanical and electronic systems. We became interested in physical computing because future architects will be called upon to design spaces and places that are computationally enhanced. Rather than simply design traditional buildings and then add a computational layer, it's better to conceive and design this integration from the outset. Preparing architectural designers for these challenges demands a range of knowledge, skills, and experience well beyond the traditional domain of architectural education. Although other departments on campus offer courses in related specific topics, none offers an integrative educational experience that prepares students for this new kind of designing. Using Gross's earlier experiences co-initiating a cross-disciplinary studio course at the University of Colorado (Eisenberg, 2002), we launched an experimental studio course on physical computing.

Figure 1a (left)- Teammates setting up the Memory Box. Figure 1b (middle)- Visitors interact with the Alphabet Paint Space. Figure 1c (right)- A skill building short project of automata design.

The Projects

Each project was designed and built by a team of four or five people in approximately six weeks.

- The Memory Box project (fig 1a) played on memory as a recording of physical experience. A large plywood x-y pen plotter uses a canvas loop as the medium. Students invented two unusual input devices: a tubular maze with tilt sensors and a soft and squishy object with bend sensors. The devices encourage physical play, driving the marker to record traces of the interaction onto the canvas.

- Laser Space used low power laser light to create the sensation of a bounded space. A spinning angled mirror reflects a laser beam, forming a conical space made visible by a fog machine. When a person approaches it, a servomotor and a wedge shaped arm interrupt the cone and create a visible entrance.
- Singing Water World created an interactive orchestra of sound and light with an interface of water fountains. When a visitor interrupts a fountain's flow, the system responds by changing the ambient sound and light.
- Alphabet Paint Space (fig 1b) uses people's motion in a space as brushes to create a painting. A video camera captures images of people moving through the space using the letters to title the painting. The processed images, which depict an abstraction of the movement, then project onto a large screen. The light painted traces fade after 10 seconds so that the video mural constantly evolves, reflecting the current state of the space.

Course Structure

We set no prerequisites. Students come with widely varying knowledge and experience, from art, music, engineering, and architecture. This challenges the course to be a collaborative open-minded learning environment that encourages individual growth and learning. Similar programs (ITP; Resnick, 2000) focus on individual projects. Our course focuses on the value of collaboration. Open-ended and multifaceted projects encourage students to capitalize on the skill set of team members. The first four weeks build skills (fig 1c) and confidence with materials, electronics, programming, and collaboration. The second six-week phase focuses on designing, building, testing, demonstrating, and documenting the integrated team project. Students learn about microcomputers, sensors, electronics, programming, materials, construction techniques, and mechanical movement. In addition, they set goals, assess progress, and work in teams to solve complex problems.

Lessons learned

We engaged students in open discussions during and after the course. We also encouraged one-on-one conversations and anonymous evaluations. The course was fun and motivating. Students described the class as "infectious" and said that they had a hard time focusing on their other studies. They often found themselves contemplating and/or working on physical computing projects late into the night when they knew they should be doing other things (such as sleep). One student told his advisors (in the informatics department) that physical computing was "the most valuable class that he has taken at the university". He said that this is because "it is the one place where people from all over campus come together as a group and use their own individual educational experiences as a foundation for the collaboration". Students willingly spent more time than they would typically spend on their classes. The first class felt that they needed more time to develop their ideas before jumping into the project. The second class recommended that we extend the experience into a two-quarter sequence. Students in the second class also requested more exposure to design ideas and methodologies. To address the perceived imbalance, we will emphasize design methodology, as well as offer more readings and discussions of design in future offerings.

Our physical computing course has successfully offered students from a wide range of disciplines an opportunity to learn from one another. Consequently, we have seen relationships and communication develop between participants from diverse disciplines. We look forward to bridging these disciplines in future editions of the course.

References

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