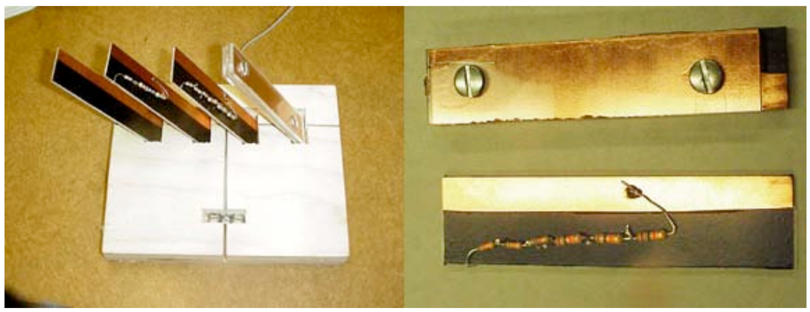
COVER PAGE

What is Physical Computing?

Here is a portfolio of student projects done at the University of Washington's Architecture Department, from 2000-2003. Most of the projects were done or begun in a ten-week course titled "Physical Computing", led by Ken Camarata. Each project explores an aspect of "physical computing" in which computation is embedded or intertwined with the built environment or physical artifacts. The electronics and computation is quite simple in these "starter" projects, but by embedding responsiveness into inanimate things they nevertheless evoke a sense of magic.

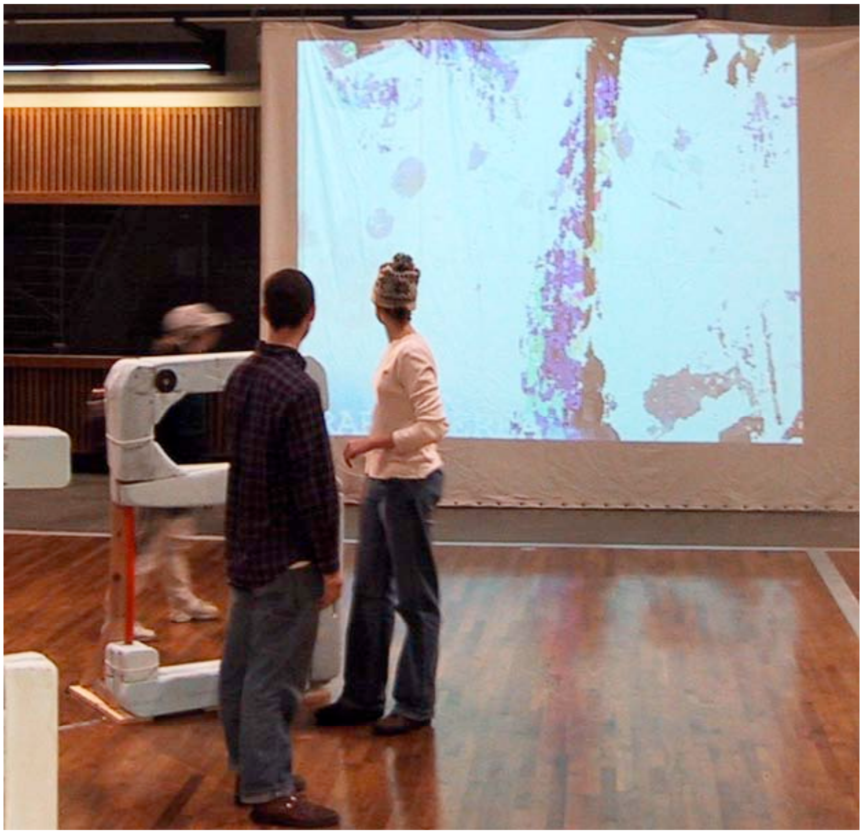
Computation has moved from mainframe hardware, to timeshared systems, to personal computing, to what Xerox PARC researcher Mark Weiser in 1991 famously dubbed "ubiquitous" computing, known also variously as invisible, pervasive, tangible, or embedded computing. This revolution in computing is driven by the availability of inexpensive, increasingly small, low power networked microprocessors and sensors for all kinds of phenomena. Where once computation was the sole province of the computer scientist, now architects and industrial designers are challenged to integrate computation into the artifacts and places that they make. The Physical Computing course at the University of Washington encourages designers to explore this *terra nova*.

The components are common enough. Ordinary materials, bought or scavenged are wired up with sensors that detect light, proximity, pressure, or bending, Motors of various kinds provide motion, relays switch on lights and other devices. Light emitting diodes illuminate; infrared beams detect motion invisibly. A microcontroller runs the whole show, perhaps connected with a desktop computer to produce a display or add audio to the experience.



Media Sticks

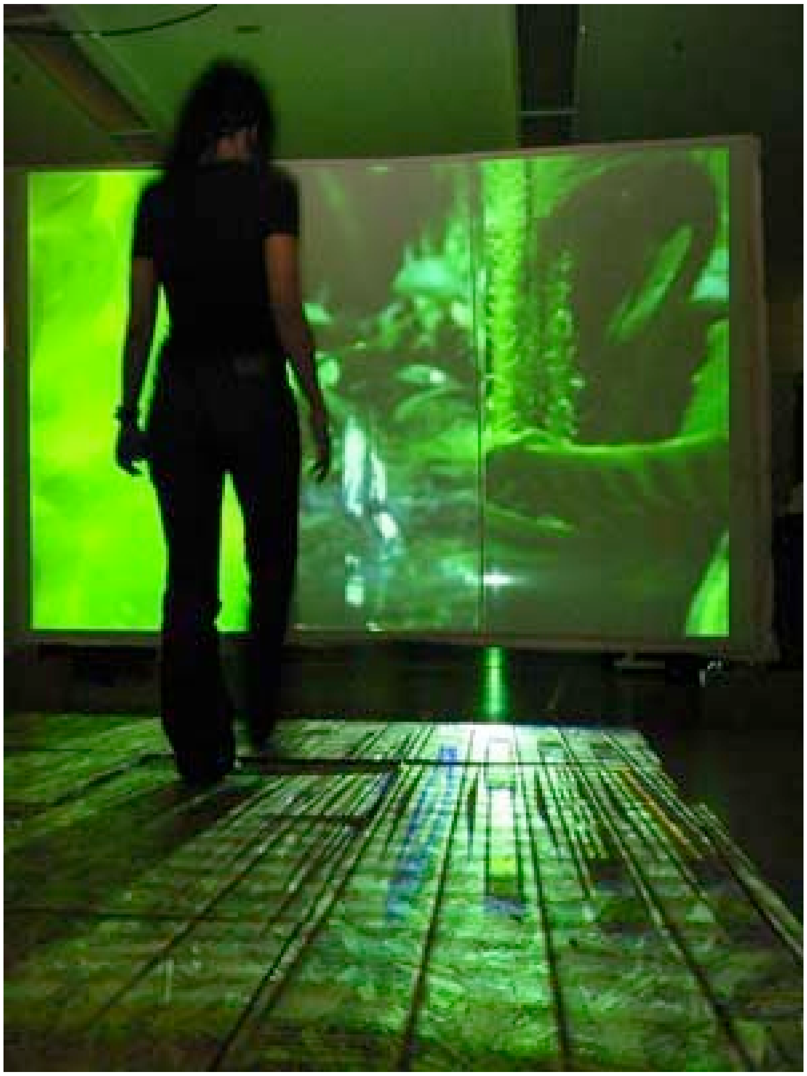
The Media Sticks illustrate how a set of physical objects that contains no data and a minimum of electronics can play a set of media files. Each Lucite stick has a resistor at one end with a unique resistance value. When you place the stick into the reader, the computer senses the resistance value, and identifies the stick and its associated music or video file. Based on the stick's id, the computer plays the appropriate media file. Although simple, the Media Sticks project reveals in a direct way how tangible objects can be used to interact with digital media.



Alphabet Paint Space

People wandering through the Alphabet Paint Space generate an abstract painting on a large screen on the wall. People stop and watch. Others wander about the space and interact with a set of large randomly placed Sesame Street style letters. Suddenly one visitor realizes that it's their movement that is generating the painting. He quickly tells a friend. People soon gather into groups and wave their arms in an attempt to manipulate the painting directly. A dancer practices a few leaps as people gather to watch the results.

Alphabet Paint Space uses people's motion as “brushes” to create a painting. A video camera captures images (15 frames per second) of people moving through the space. The processed images, which depict an abstraction of the movement, then project onto a large screen at one end of the hall. The resulting light-painted mural traces movement that fades slowly over time. The traces disappear so that the mural constantly evolves, reflecting the current state of the space. To encourage movement, four-foot high letters populate the space, each containing a photocell. As people pass in front of a photocell, its letter appears at the bottom of the movie screen, as if writing an abstract title for the abstract painting created by the image processed video.



Plant Tiles

A six by ten foot platform sits in front of a rear-projected screen with the words Plant Tiles and green imagery projected on it. When you step onto the platform, the title disappears and part of the projected video sequence plays to a key frame. Walking toward the screen plays the sequence forward. Walking backward plays it in reverse. Side to side movement triggers different segments of the projection. Your movement and connection to the ground affects the transformation of the plants and reinforces the connection between the earth and plant life.

Plant Tiles began with an underlying educational goal. Starting from the concept of "transformation" and applying it to cycles of growth in plants, the project maps three video segments (in Director with Lingo scripts to control playback speed and video sequence) to a pressure sensitive floor built of plywood, wood blocks, aluminum foil, and polyurethane foam. The three videos showed time-lapse photography of three plants. By moving around the space you control the individual growth of the plants. The results are visually rich. Abstract audio clips accompany the transformation of the plants, engage and encourage you to interact.

Laser Space

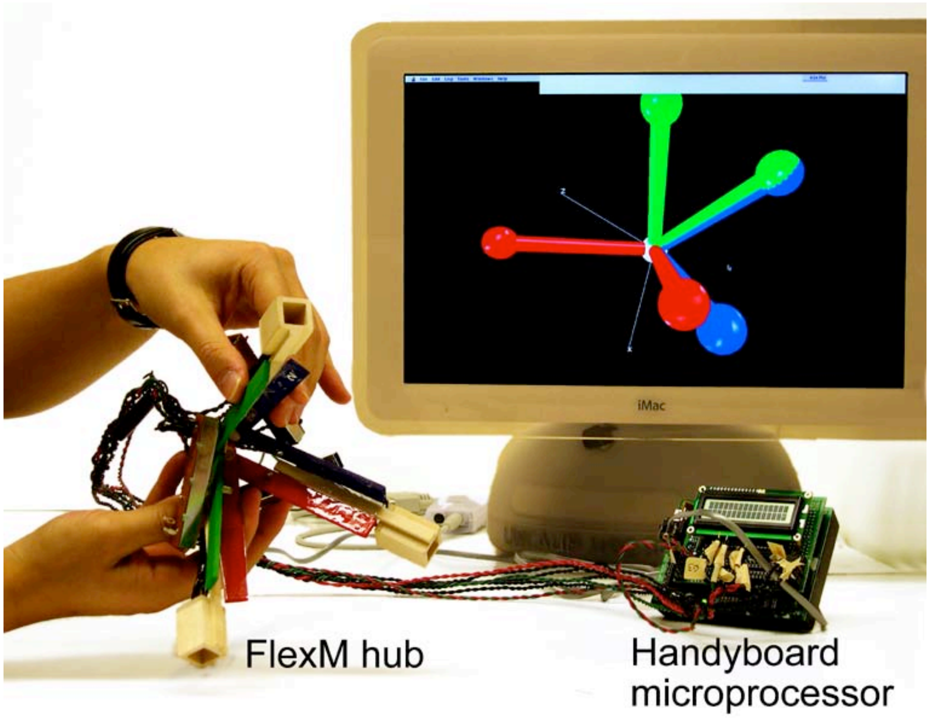
People eagerly squeeze into the dark space. In front, at waist height, a single red line of light stops them from moving forward. Beyond, a cone of red light fluctuates with the shifts in the fog that fills the space. Urged to move forward, a person breaks the single line that forms the barrier. In response, the side of the cone peels open to reveal an open volume of space and exposing a pedestal that houses a machined metal joystick. Stepping inside the cone, the person moves the carefully crafted joystick. As a result, a third laser mounted to the back of the pedestal turns and plays its beam across the walls beyond the cone.

Laser Space uses low power laser light to create the sensation of a bounded but nonphysical space. A DC motor spins an angled mirror to reflect a laser beam, forming a cone made visible by a fog machine. A break-beam sensor composed of a laser (visible as a red line of light) and a photocell "opens the door" when a person approaches. A servomotor interrupts the cone with a wedge to create a visible entrance. Inside the space, visitors interact with a third laser on a servomotor robotic arm using a joystick built out of two potentiometers.

Jungle Room

The room is filled with vines, trees, and leaves and it smells of the jungle. Several large cartoon animals peek through the branches as the room tells a story on its audio system. “Help! I’m a jungle boy who has lost his toy. Can you talk to the animals and help me find it?” Focusing on a non-linear narrative about a jungle boy, this project teaches young children facts about a few animals. As children interact with the cartoon animals in the space, they trigger audio clues that tell them which animal to visit next. “ I do not have the toy, find the animal with no feet.” If they approach the wrong animal, it lets them know and provides another clue. “I am not the animal that you seek, try the one who can’t move his eyes.”

A Java program on the host computer reads signals from the Handyboard microcontroller; the system knows which animal is being addressed, what clues have been given, and to what set of speakers to distribute the sound. The sequence of animals changes, and clues are randomly selected to encourage repeat visits by providing a different experience each time.


iMac
FlexM hub
Handyboard
microprocessor

FlexM

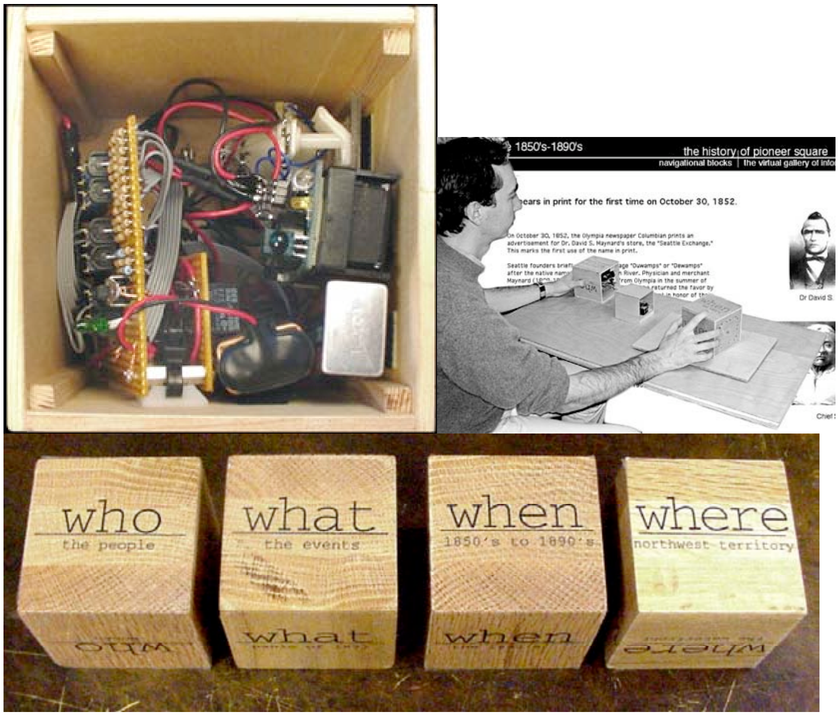
FlexM is a flexible physical interface for making and manipulating digital models. The crafting of form is a dynamic process in the designer's hands using the FlexM components of hubs and struts. In place of clicking and dragging with a mouse interface, the designer builds the model with FlexM hubs and struts. With flexible joints on the hubs, the designer can sculpt models that transform dynamically. The hubs transmit parametric information to the computer, which renders the model on the screen in real time. This allows the designer to create complex forms with the fun and directness of playing with a toy.

Music Under Pressure

Settle into the comfortable cushions and this couch emits soft soothing lullabies—reach your arm over the back and it whispers a melody. Stand up, and a tattoo of tympany salutes you. In short, this couch is a musical instrument. It uses MIDI synthesized sound triggered by people sitting on it. Simple home-made pressure sensors are embedded underneath the cushions, infrared rangefinders in the arms, and tap sensors in the back to create a musical couch that could easily blend into the playful environment of the Experience Music Project music museum in Seattle.

Window Seat

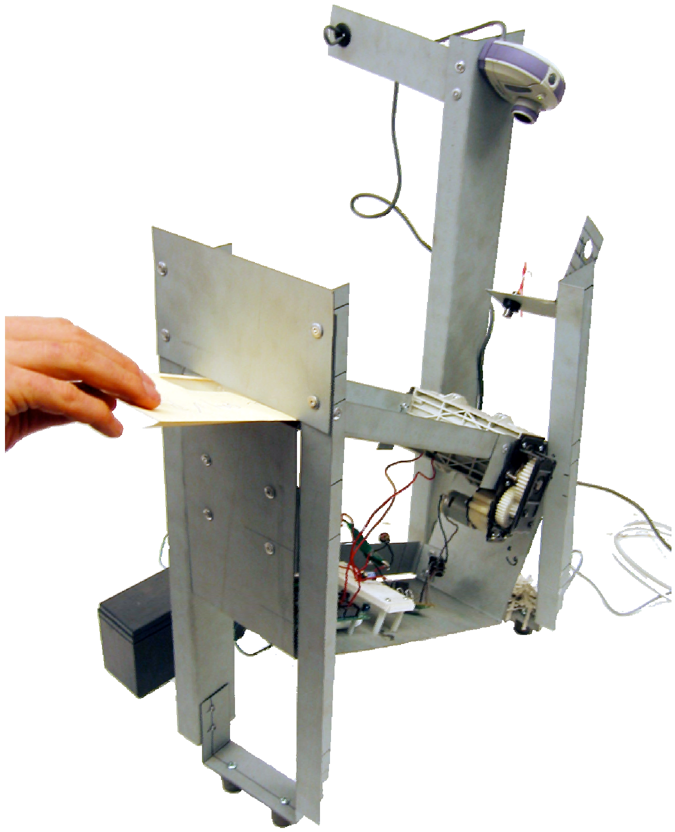
Conceptually, this project uses the rock and swivel of a chair as an interface for a pan and tilt camera. A rocking chair controls the up/down tilt and a set of pressure sensors to control the left/right pan. A small camera is placed inside an architectural model, and a projector mounted inside the chair and a mirror displays the camera's current viewpoint on the wall in front of the chair. In effect, the chair's occupant can visually occupy a scale model. In future versions the camera could be located in a geographically remote location, or be a viewpoint into either a nano-space under a microscope or a virtual environment.


1850's-1890's
the history of pioneer square
who
the people
what
the events
when
1850's to 1890's
where
northwest territory

Navigational Blocks

Imagine exploring downtown Seattle. You encounter kiosks housing virtual galleries of historical information. At one kiosk you find four Blocks sitting in front of a computer display. The Blocks represent categories of Who, What, Where and When, with titles printed on their faces. One face reads 'Who – the People'. The remaining five sides represent subtopics: founding fathers, women, merchants, native Americans, and miners. When you place the block in the 'active area,' the system tells stories about the people in Seattle's history. When you place more than one Block the system combines individual queries. Playing with the Blocks and viewing the results, you explore the history of Pioneer Square.

Navigational Blocks are a tangible user interface that facilitates retrieval of historical stories in a tourist spot. Orientation, movement, and relative positions of physical Blocks support navigation and exploration in a virtual gallery of information. The Navigational Blocks provide a physical embodiment of digital information through tactile manipulation and haptic feedback. It is easy to understand the simple cubic form of the Blocks and therefore to manipulate complex digital information. Electromagnets embedded in the Blocks and wireless communication encourage rapid rearrangement to form different queries into the database.



Junk Mail to Spam Converter

As computers spread out from the desktop into the environment they threaten to compound the problem of clutter in our physical spaces. To offset this trend physical-to-virtual filters can shift superfluous physical objects into the virtual realm and free up physical space. The junk mail to spam converter does not solve the problem of junk mail, it transforms it into spam so that it no longer intrudes on our limited physical space.

Intended as your constant companion at home or in the office, the JMtoSC is a sculptural object. Like the three-headed dog at the gates of hell, this sheet metal Kerberos shreds your mail's physical instantiation and casts its digital memory off into the abyss of your inbox.

When a letter is fed into the slot in the front of the sheet metal structure, it slides down a chute through the JMtoSC's innards where it triggers a breakbeam made of a laser pointer and a light sensor. A handy board bolted into the guts below listens for the beam to be broken and signals an applescript program to snap a photo of the doomed missive and send it to your email account before the handy board flips the relay controlling to the shredder in the bowels of the beast and grinds the letter into compost.

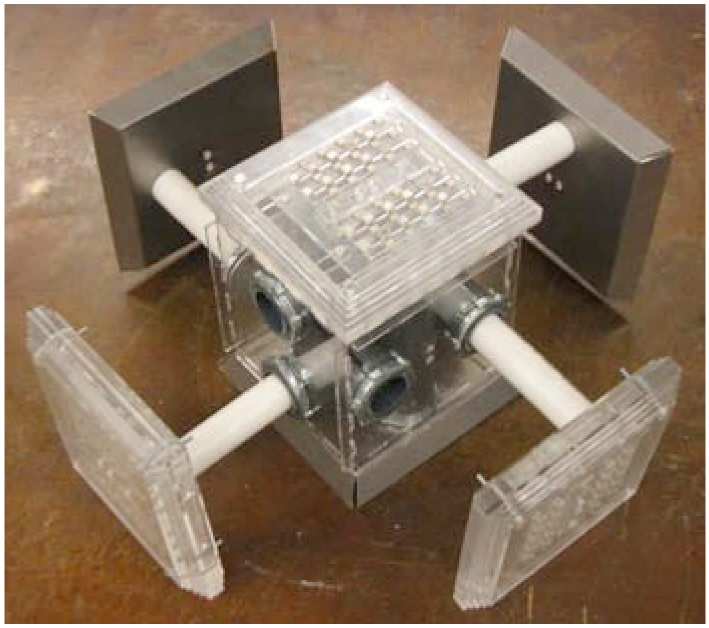
Memory Box

Visitors take turns playing with a yellow ceramic tube with a ball bearing rolling through a maze wrapped around its exterior surface. Although playing with the tube maze is their initial impulse, soon the visitors move to the other side of the display to watch the xy plotter recording their interactions with the maze.

The Memory Box project plays on memory as a recording of physical experience. It is a large xy pen plotter built of plywood with a marker recording on a canvas loop. Two unusual input devices drive the memories: One is a "tubular maze"—a ceramic cylinder the size of a paper towel roll with a maze cast onto its surface, wrapped with a nylon stocking. It contains tilt sensors that report the users' manipulations of the maze to the Memory Box's microcontroller. The second device is a "soft and squishy" object made of a rubbery gel (like that used for keyboard wrist rests) with embedded bend and pressure sensors. The peculiar devices encourage physical play, driving the memory box's marker to record traces of the interaction onto the canvas.

Energy Cube

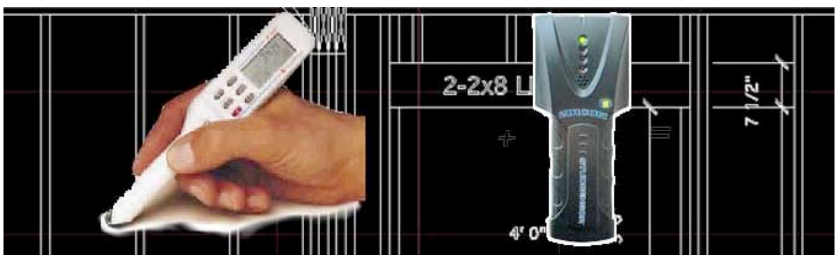
The Energy Cube is an ambient display for energy consumption in the home. Each face is mapped to a zone in the house. By rotating the block such that the zone of interest is facing up, the block glows shades of blue, purple, and red to indicate the energy being consumed in that zone.



Espresso Blocks

Robotics researchers have been experimenting with robots that are composed of a number of robotic ‘cells’ that are all identical, rather than designing a robot that has a variety of different parts each designed to perform a certain function. These cellular robots can take different configurations in different situations, and some researchers have proposed robots that would invent new configurations for themselves to deal with unforeseen situations.

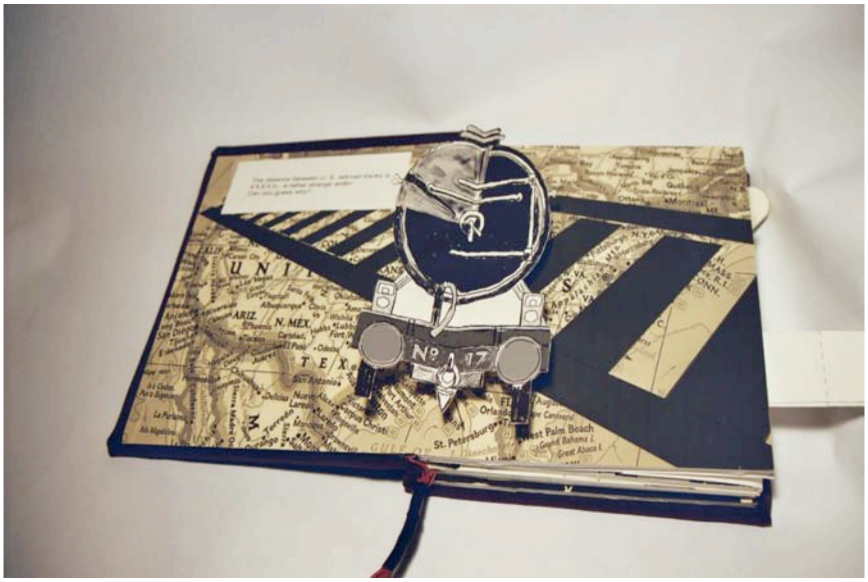
Espresso Blocks are cellular robotic building blocks that are delivered to a site on a pallet and then assemble themselves into one of several pre-configured structures. Using a remote control, the occupant can cycle between different structures throughout the day to accommodate different activities such as an espresso stand during the day, a dining room in the evening, and a bedroom at night. The occupant can also rearrange individual blocks with their remote control to create new configurations, save them to their remote, and even trade designs with others.


2-2x8 L
7 1/2"
4' 0"

StudSketch

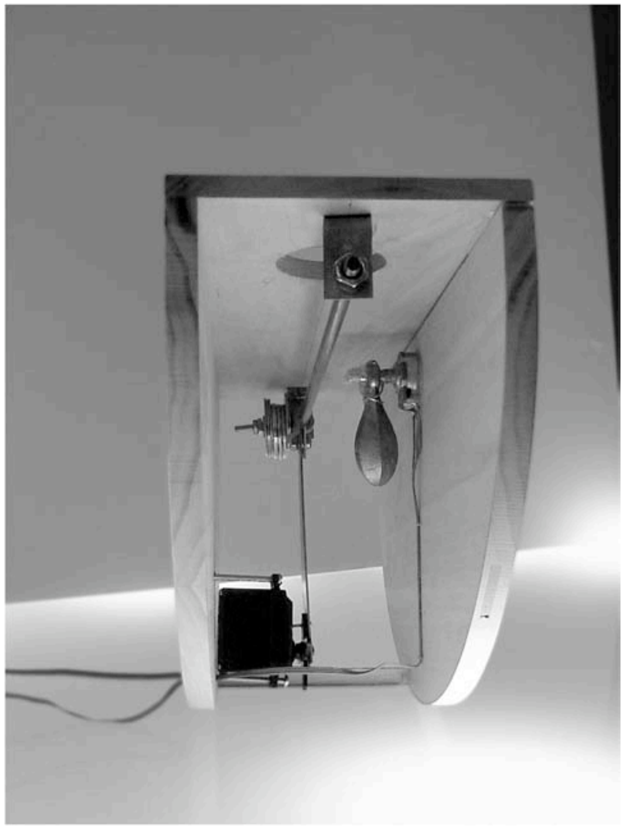
StudSketch allows you to see inside walls, using a commercial stud finder coupled with a digitizing pen (Mimio) and a projector. After calibrating the Mimio digitizer and projector on a section of a wall, drawing on the wall with the StudSketch pen reveals its contents, displaying the studs and pipes that are hidden inside.

StudSketch interfaces an inexpensive Studfinder with a Mimio pen, using a general purpose transistor (2N2222) as a switch. The transistor is attached to the Studfinder's buzzer leads and switches the battery on the Mimio pen. A bypass switch added to the side of the Studfinder allows for manual control of the Mimio pen and easy calibration of the system.


Nº 17
ARIZ.
N. MEX.
St. Petersburg
West Palm Beach

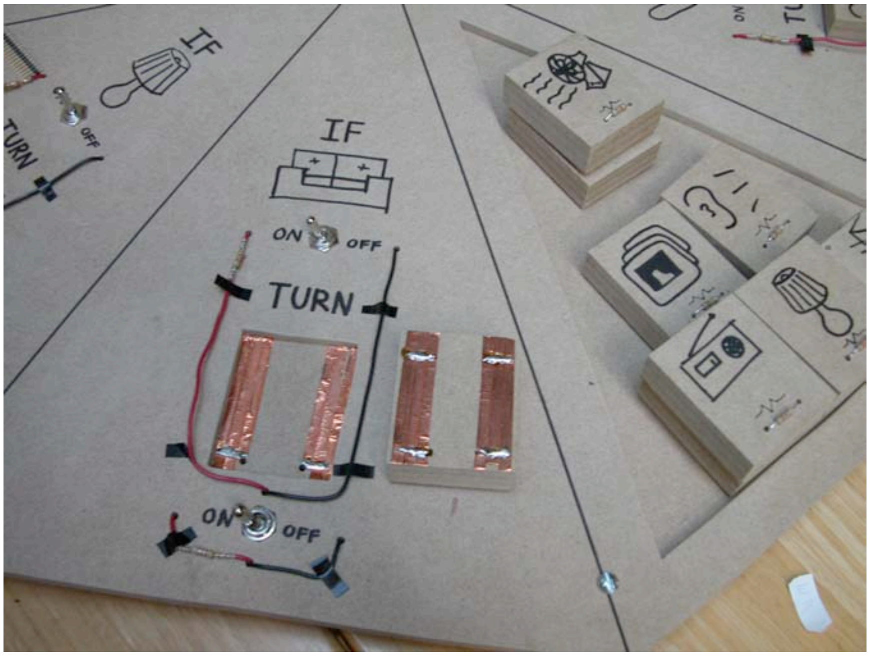
Pop-up Book

This paper pop-up book has light sensors embedded in its pages, and it's linked to a desktop computer. When the reader operates the pop-up features (by pushing or turning a strip of paper), one of the light sensors is exposed to ambient light in the room. The microcontroller in the book notices this, and relays the information to the desktop computer, which augments the story on the pop-up book page with a video or audio supplement.



EQUATE

Using the Montessori principles of isolating specific senses, Equate incorporates balance, cause and effect, and the prisoner's dilemma into an interactive game. Two participants begin a balance game where each player's actions affect the location of the fulcrum of the opposing player's object, thus affecting the balance of the object. The balance toys are made of wood and metal parts in which the weights are a series of unmarked ball bearings and the user is limited to placing the weight in one designated location. The object of the game is to cause both semi-circular objects to balance simultaneously achieving homeostasis despite the fact that each player has added or removed an unknown weight.


IF
ON
OFF
TURN
ON
OFF

STARS

In STARS (Simple, Tangible Action Response System) you program interactions in the room using a tabletop interface. Select the block that corresponds to the object whose state you wish to change (from on to off or vice versa), place it in the appropriate slot in the board, and flip the toggle switch.

You then interact with the room and the room carries out the programming. For example, place the TV block in the Lamp board, and toggle the switches so that when you turn off the light the TV turns on. Then sit down with a bowl of popcorn, turn off the light and watch the movie. This is only one simple interaction. Multiple functions can be called, and more complex interactions will occur as a result. The purpose is to teach the principles of object-oriented programming. Also, exploring different programming combinations within the room, exposes users to a new level of interaction with an ordinary environment

Gender Re-render

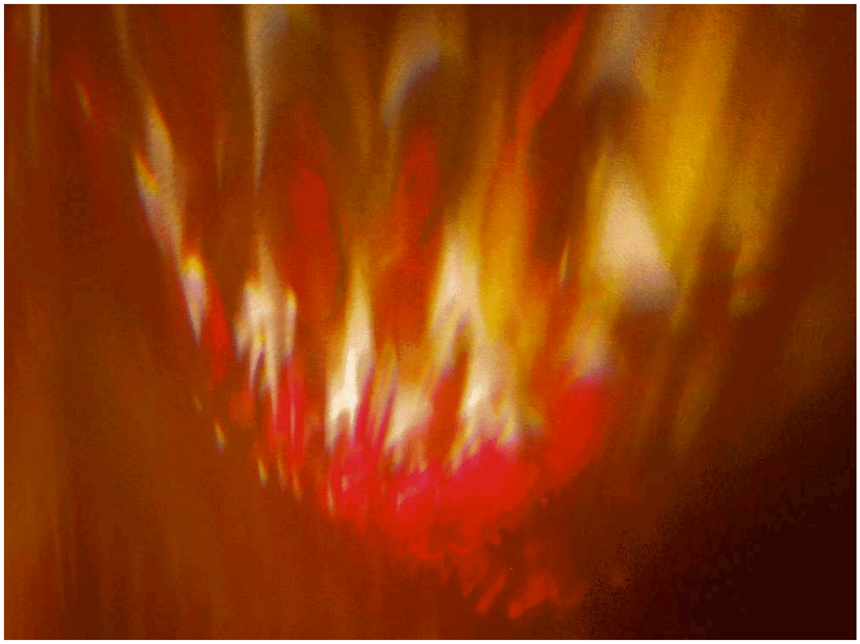
In a sound-and-video-wired restroom motion sensors triggered audio stories. Anyone entering the urinal-equipped men's room could hear men's personal stories narrated by women, and those in the women's room heard women's stories told by men.

LEDerman's Jacket

The LEDerman's Jacket directly introduces light and interactivity to fashion design. The initial concept was to create an LED matrix on the back of the jacket that would respond to the wearer's actions that would pictorially represent everyday choreography of movement. Its images are of the well-known character Mr. Potatohead, but the technology is receptive to almost any design. The jacket's wearer expresses agency through actions, which stimulate programmed responses from the light emitting diode network on the jacket. Inherent jacket actions—hands in pockets, button use, raised collar—light up Mr. Potatohead's various facial features: nose, glasses, and eyebrows.

Nitinol Lamp

The Nitinol Lamp is made of translucent ribbed plastic panel material and lit by a 60 watt incandescent bulb. Heat from the bulb contracts a spring made of Nitinol shape-memory alloy wire, which mechanically switches the lamp off. When the bulb is off, the Nitinol wire cools and expands again, which turns the lamp back on. The lamp cycles indefinitely.



Energy Kaleidoscope

Energy Kaleidoscope is an ambient display device that encourages people to be conscious of the amount of electricity they consume at home. It generates large, brilliant, and endless unique kaleidoscope-type light patterns on the neighboring walls and ceiling. The less energy consumed in the house the brighter and the more stimulating the patterns; conversely, the more energy consumed the dimmer and the more diffused the patterns generated.

A spotlight plays through a rotating plexiglass disk with colored glass, gemstones, and other translucent objects. A series of lenses and prisms focuses the beam and adds further color effects to the display. Sensors throughout the home determine the total energy draw, which is translated to the brightness of the spotlight. This in turn generates more or less sensuous visual imagery.

<film pretzel pix here>

Top Hat

<PICTURE OF SHAOW PRINTER HERE>

credits

Alphabet Paint Space
Travis Beck, Mathew Chasan, Kailin Gregga, Jeffrey Lopez
Memory Box — Michael Weller, Julia Cole, Don Craig, Todd Smith
Laser Space — Thane Champie, Andrew Kwong, Richard Lotz, Leigh Rosser
Jungle Room — Irene Chin, August Graube, Jesse Pons, Jeff Towle
Plant Tiles — Dan Dean, ChenJe Huang, Jennifer Zwick
FlexM — Markus Eng
Navigational Blocks — Kennith Camarata
JunkMail to Spam — Michael Weller
Top Hat: — Ian Li …
Film Pretzel — Orit Shaer, Babak Ziraknajed, Todd, Julius
Gender ReRender — Genessa Krasnow, …
Nitinol Lamp — Michael Weller
Espresso Blocks — Michael Weller
Window Seat — Doo Young Kwon, YeonJoo Oh, Jennifer Lewis, Babak Ziraknajed
Music Under Pressure — Colin Bleckner, Laura MacCary, Golnaz Mohammadi, Mike Tetzloff
LEDerman's Jacket
EQUATE
PopUp Book
STARS

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