Design Research

METHODS AND PERSPECTIVES

Brenda Laurel, editor

The MIT Press
Cambridge, Massachusetts
London, England

Cover and book design: The Offices of Anne Burdick, Los Angeles
Designers: Anne Burdick, Stuart Smith, and Megan McGinley
Cover photo: © 2003 Susan L. Burdick

Library of Congress Cataloging-in-Publication Data
Design research : methods and perspectives / [edited by] Brenda Laurel.
p. cm.
Includes bibliographical references and index.
ISBN 0-262-12263-4 (hc : alk. paper)
1. Engineering design. I. Laurel, Brenda.
TA174.D483 2003
745.2–dc22 200359969
10 9 8 7 6 5 4 3

CONTENT CATEGORIES

		PEOPLE								FORM						
		CHRISTOPHER IRELAND 23	TIM PLOWMAN 30	BONNIE JOHNSON 39	ERIC DISHMAN 41	BRENDA LAUREL 49	CARLOS SANTOS 55	STACEY PURPURA 63	ABBE DON, JEFF PETRICK 70	LISA GROCOTT 83	DENISE GONZALES CRISP 94	ANNE BURDICK 101	RACHEL STRICKLAND 118	MICHAEL NAIMARK 109	EMMA WESTECOTT 129	ROB TOW 135
RESEARCH METHODOLOGIES	EXPERIMENTAL							●			●	●	●	●		●
	QUALITATIVE	●	●	●	●	●	●		●				●			
	QUANTITATIVE						●	●	●							
	SPECULATIVE		●	●	●					●	●	●	●	●	●	●
	EXPERIENTIAL		●			●							●	●		
	PERFORMATIVE			●	●	●										
	DISCOVERY-LED/POETIC									●	●	●		●	●	
	FORMAL/STRUCTURAL										●	●	●	●	●	●
	PROCEDURAL	●	●			●	●		●	●		●	●			
CONTEXTS	COMMERCIAL	●	●		●		●	●	●	●						●
	ACADEMIC		●			●				●	●	●			●	
	EXPLORATORY	●	●	●	●	●			●		●	●	●	●	●	●
SUBJECTS	DESIGNER			●	●	●	●		●	●	●	●	●	●	●	●
	DESIGNED OBJECT	●		●	●	●				●	●	●		●	●	●
	USER/CUSTOMER	●	●	●	●	●	●	●	●				●			
	ORGANIZATION						●		●	●						●
DOMAINS	PRODUCTS/SERVICES	●		●	●	●	●	●	●	●						●
	THEORY		●	●	●	●				●	●	●	●	●	●	●
	PRACTICE	●	●	●	●	●	●	●	●	●	●	●	●	●		●
	GAMES/ENTERTAINMENT														●	
	BRAND									●						

CONTENT CATEGORIES

	PROCESS												ACTION								
	DARREL RHEA	NATHAN SHEDROFF	SEAN DONAHUE	DOROTHY DEASY	ERIC ZIMMERMAN	ERIC ZIMMERMAN	PATRIK SVENSSON	BJ FOGG	CHRISTOPH LOCH	SOMI KIM	TRACY MOON	DAVID CANAAN	HENRY JENKINS ET AL.	WILL WRIGHT	DARION RAPOZA	MARGARET DAVIS ET AL.	BRUCE DAMER	JIN HYUN PARK	BUFFY SHUTT	JAN CRAIGE SINGER	DAVIS MASTEN
	145	155	164	172	176	185	193	201	212	221	225	234	244	253	260	268	276	285	293	301	309
RESEARCH METHODOLOGIES					●								●		●	●	●				
	●	●	●	●			●		●	●	●	●	●	●	●	●	●	●		●	●
	●						●							●	●	●			●		●
		●					●	●									●		●	●	●
		●	●		●	●			●		●	●		●	●	●	●	●			
					●												●				
							●													●	
			●										●					●			
	●		●	●	●		●	●	●	●		●	●			●			●		●
CONTEXTS	●			●	●	●		●	●	●	●	●	●	●	●	●		●	●	●	●
							●						●		●						
		●	●	●		●	●			●	●	●	●	●			●	●		●	●
SUBJECTS	●	●	●	●		●	●	●	●	●	●	●	●	●			●				●
		●			●						●		●	●	●	●	●	●		●	
		●		●	●					●			●	●	●	●	●	●	●	●	
	●					●		●	●		●										●
DOMAINS	●		●	●					●	●		●			●		●	●			●
							●						●		●						
	●	●	●	●	●	●	●	●	●	●			●	●			●	●		●	●
					●								●	●	●	●	●		●	●	
	●									●	●	●							●	●	●

Strategy, Tactics and Heuristics for Research

A Structuralist Approach

ROB TOW

Grand Strategy, Strategies and Tactics

Deciding "What to Do Next" (and How to Do It) is a problem I've faced repeatedly in my career. Over time, I've developed an approach that has a definite structure. Much of it is inspired by the thought of several historians of military history, combined with a wry appreciation of some of the valid points of deconstructionist philosophers. I combine these tropes into a method for conducting research for inventive design—that is, the design of that which is novel.

Liddell Hart, the military historian, wrote of a three-level top-down structure to the struggles between nations. He called the top level "grand strategy." It is the single overarching high-level end goal; for example, to defeat the Axis, or to eradicate Carthage. An example in design would be Microsoft's desire to dominate the desktop. The next level down is that of "strategies." Liddell Hart described strategy as "the art of distributing and applying military means to fulfill the ends of the war." The bottom level is "tactics" [Hart 1991].

A grand strategy is typically supported by more than one strategy (the second level down). Strategies are distinct patterns of action. Examples in war are daylight strategic bombing, guerrilla warfare and blitzkrieg combined-arms maneuver. In research, examples are Edison's strategy of methodically testing thousands of substances for the filament of the incandescent light-bulb [Schivelbusch 1995], or Goodall's careful observations of chimp behavior [McGrew 1992]. Both of these latter are "dialogues with Nature," where previous understandings lead to a choice of observations and measurements, with expectations that may be contradicted by what Nature actually does. In business, Microsoft's "embrace and enfold" is a powerful strategy. In design, think of Nokia's targeting of the teen market.

Strategies are supported by tactics. These are the details in the small of battles, the day-to-day struggles. They change rapidly. Examples are the infantry assaults on pillboxes on Omaha Beach and the use of MP3 as a format by Rio to sell music hardware. Nokia's downloadable ring tones and swappable covers are tactics supporting their strategic focus on the teen market.

Many workers in research and in design start their efforts by falling in love with a whizzy strategy—or worse yet a mere tactic—and then try to dream up something grand to do with it. This is like the Polish obsession with the glory of horse calvary tactics at the eve of WWII, doomed to failure in competition against Guderian's panzer divisions.

Let's take these three levels—grand strategy, strategies, and tactics—as a given structure, and observe that starting from the top level and working down is a powerful way to proceed with an economy of effort. Nothing at the lower levels is accepted except that which supports the next level up.

Finding the Void

Sun Tzu observed that direct assault on fortified cities was the most costly and dangerous strategy. It is more effective to appear where one is not expected [Sun Tzu 1971]. What is the corresponding maneuver in research and design? It is to find the "void"—the unpopulated area where nothing yet exists.

This observation sets a meta-requirement for strategic thinking: to find the void. I approach this in a structuralist manner, describing the essential qualities of an existing design space, technology or user experience and then imagining inverting a small number of its specific qualities. In a way, this is akin to the deconstructionist creation of the "other" by knowing the "self," or to inferring the nature of a lost text by inverting its triumphant Hegelian opponent [Culler 1983]. For example, consider a conversation between two people. In days ancient and now forgotten conversations were all face-to-face. The opposite (inversion) of this is to have bodies separated in space. Let's think of describing this structurally as a number line, with face-to-face at the left end at (0), a shouted conversation across a canyon a little to the right (0.3)—and a telephone conversation at the far right (1). We now have three points along an axis. One could imagine building something to populate the unoccupied point at (0.6)—perhaps a super-megaphone?

We can imagine a new axis, at right angles (the "y" axis) to the first (call the first axis "space"), and call this new axis "time". What would excursions along it be like? Well, face-to-face is at the origin and a recording is at the top of the y-axis. We now have a Cartesian grid, with tape recorders at (0,1), face-to-face conversations at (0,0) and telephony at (1,0). And there is a void—an unoccupied locus—on the grid at (1,1). Clearly, its "nature" would be a recorded conversation between two people far apart in space and separated in time.

In other words, voicemail.

Can we add a third axis? Perhaps that of other media types? This rapidly takes us into what is now the domain of instant messaging services, which are all populating new loci in "conversation space." Perhaps we can even add a fourth axis: the number of people involved.

Notice that many of the loci exposed by such a structuralist analysis are dependent on having technologies to create capabilities to support their intent. Often such capabilities are logistical in nature, as in the telephone network—but they can be re-purposed to support a new intent revealed as part of a structuralist design process—just as the telephone network was re-purposed to be used by the first computer modems to transport digital data over analog voice lines by the

Strategic Air Command's SAGE network in the 1950s [Edwards 1997]. Cleverly repurposing existing logistics is an important heuristic for design. But sometimes there is no way to create the capability that can populate the void—we call this "unobtanium."

Nonetheless, we now have a powerful analytic tool for design. We describe experiences and affordances, creating a Cartesian multispace, and note where existing things cluster. Then we observe where the unpopulated loci are and describe their nature in terms of experience and affordances. Then we analyze the technology needed to support their existence and proceed to actual engineering.

Resource constraints and social factors can cause problems in engineering. I'll examine these and illustrate them with some examples from my own experience. First, let's look at resource constraints.

The Russian Sleigh Ride

Years ago I saw a painting of a horse-drawn sleigh racing across the Russian steppes, chased by wolves. The people in the sleigh were throwing cargo out, lightening the load to escape. In my memory a woman was holding a baby and looked to be desperately thinking of tossing the infant to the wolves.

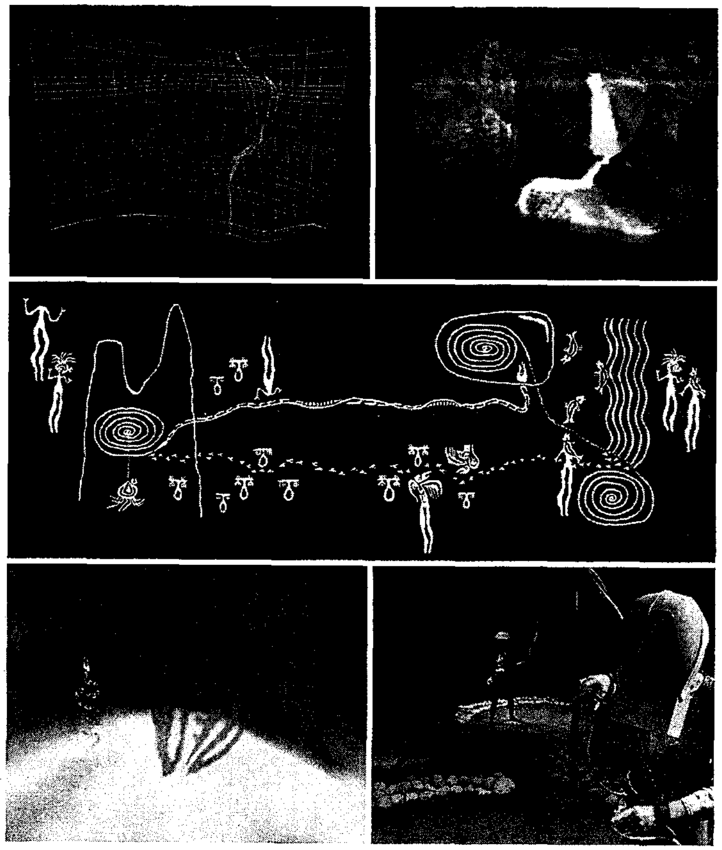
This painting provides a metaphor for what to do when you have a design with many features—a lot of cargo—and you are being chased by constraints in resources—time, money, staffing, etc. You have to lighten the load.

In what order do you throw things out?

This problem arose in a project that I worked on with two brilliant designers, Brenda Laurel and Rachel Strickland: the *Placeholder* virtual reality project at the Banff Centre for Arts. We had planned an elegant and ambitious design for a multi-person and multi-world virtual reality installation, with 3D spatialized audio, manipulable virtual objects, field recording of visual and audio real-world locations, elaborate avatars as petroglyphic spirit animals that would transform the participants' "bodily" appearance, a rich multisensory environment and transformations of participants' spoken voices. Due to a scheduling collision at the Banff Centre, we found ourselves with six weeks to do six months' worth of work. The chief programmer had a nervous breakdown, and the head of the program panicked and demanded that we build something much simpler—one person, one world, no spatialized audio, no fancy avatars.

I thought hard about this, and for the first time did an explicit structural analysis of a design. He wanted one person; we wanted a social experience. He wanted one world; we wanted multiple worlds. He wanted no avatars; we wanted "smart costumes" where people could be embodied as Spider, Fish, Snake and Crow. We wanted to let people record snippets of narrative to leave behind in the virtual worlds and to let them fly like birds when they were embodied as Crow; he wanted a simple walk past a landscape, with no shared history.

I made it my goal to make a plan that preserved as large a space as possible—



Placeholder virtual reality project.
Top: The wireframe virtual relief projection of the waterfall and its ultimate appearance.
Middle: A graphical-narrative "map" of the Placeholder worlds.
Bottom: Snake and Spider in the cave environment, as the participants are seen from inside and outside of the virtual world.

a volume within the multiple axes of social experience, multiple worlds, affordances and sensory experience. I tossed out elements that did not increase the enveloped volume within the design space—for example, we got rid of the mosquito that I had programmed to pester participants by buzzing around their heads—and we abandoned an effort to map bodily movements to "wriggles" in the bit-maps of the petroglyphic avatars. We did not implement sensory transformation models for the special qualities of vision for the Crow avatar, or for the Spider. Working with the programming and design staff, a plan was made that conserved the excursions along the structural axes, preserving the volume in the hyperspace of the design elements. We tossed a lot of stuff out of the sleigh.

We met our performance date. It was a Russian Sleigh Ride exercise of desperate order that preserved the baby. And yes, people did fly through the Three Worlds when they were Crow [Laurel et al. 1997].

Action in the Polis (1)—Hail Imperator

Some of the problems in design, and in expressing design in engineering, are social. Action can be hard to achieve.

The fighter pilot, designer and strategist John Boyd did the first thermodynamic analysis of air-to-air combat. He translated his mathematics into the design of the F-16 and the A-10 "Warthog"—machines designed for very different roles. He also originated a cognitive and social model called the OODA loop—"Observation-Orientation-Decision-Action." Individuals (fighter pilots) and organizations (companies) both iterate this loop in their behavior. Boyd observed the importance of actually performing each step of this loop, and in shortening its standard delay. "Getting inside your opponents loop" (e.g., acting faster on similar data) is an important heuristic for a fighter pilot—or a design team [Coram 2002].

An organization has to be able to actually perform each step of this loop. Sometimes the hardest part is the "decision" part—particularly in organizations that profess to operate by consensus. Committees have a hard time making decisions. When decisions can't be made explicitly, according to the social contract, they will be made covertly, and the confidence of the group in its process—and therefore its will to succeed—will be lost.

This problem also arose in *Placeholder*. There were two co-directors with very different artistic aesthetics. There were weekly design meetings. At the time of the crisis, there was no agreement between the co-directors. A *coup d'état* eventuated, in which the technical staff (the sergeants) threw its support behind one of the directors (a captain), resulting in fast action on a unified design. The problem was the original structure of command and control—it was not unitary.

Designing the social structure of a design team should be done in such a way as to make the OODA loop work. This is best done by a hierarchical tree, with local autonomy residing in one person at every level. This should funnel to one person at the top. Discussion and feedback, both public dialogue and Japanese-style back-channel conversation to preserve face, are important—but so is the ability for decisions to actually be made and acted on. The wise leader listens to her subordinates, and also is not afraid to do what she decides is correct—and to expect to be followed.

At the banquet at the end of the *Placeholder* project I rose to my feet, and toasted the triumphant director with the ancient salute of the Roman legions to a commander they felt was worthy to lead them into battle—hail Imperator!

Action in the Polis (2)—The Laurel Maneuver

I am indebted to Brenda Laurel for the following insight concerning strategy and grand strategy.

Brenda is a *Star Trek* fan of great enthusiasm. Her favorite character is James T. Kirk. Kirk is famous in the grand narrative of *Star Trek* for finding "the third alternative" in win-lose situations. Brenda has been heard to challenge her staff to "find me that third alternative!"

A problem facing many designers is an ethical one. How can you work for a company that has a grand strategy that is problematic for you? Brenda's insight is that a designer can sign up to work on a specific strategy that can serve two different grand strategies—one grand strategy that the company desires, and a different one that the designer desires.

Consider a feminist working for Nike. Nike wishes to sell more shoes than anyone else. The feminist wishes for certain oppressed groups to increase their well-being in the world. These are different grand strategies. However, the strategy of designing an ad campaign to enhance selling running shoes to women can be enthusiastically shared by both—because it sells more shoes, and because it increases the physical well being of women to run.

I call Brenda's insight the Laurel Maneuver.

Action in the Polis (3)—Sanjuro: The Ronin Leaves Town

My first really good design inversion came to me when I was working at Xerox PARC in the late 1980s. I had spent several years working on color printing, digital halftoning, image processing—pushing pixels. One day at lunchtime I was sitting in the cafeteria, reading Jacques Vallee's book on the sociology of belief in UFOs as one of my co-researchers excitedly exclaimed "... and we can hyper-link all the pages by putting a barcode on the bottom of every page!"

Now, I had designed digital typefaces. Good type and the aesthetics of page design are important to me. So I looked up from my book, and said: "That would be *fugly*!!!"

Suddenly it flashed on me that there was an alternative—one that not only would not be ugly, but also could achieve a much higher data density.

The insight came from my knowledge that halftoned pictures are made up of dots of various sizes—dots that are usually shaped as ellipses, oriented at 45 degrees. This is done digitally in a way that apes the way it has been done photographically for 150 years. The key was that in the analog world the dots all line up in the same direction, but in the digital world—with control over every dot in ways not possible with an analog halftone screen—one could make the ellipses tilt to the left and denote a zero—and tilt to the right to denote a one. This could embed information within an ordinary picture, at rather high densities, in a two-dimensional grid [Tow 1994].

The technology was the easy part. Getting a gigacorp to actually use it was the hard part. I also discovered that a senior researcher was stealing credit for my idea. Fortunately, I had documented my insight, and got the basic patents nailed down. But I grew dispirited. I was in love with the beauty and elegance of the idea, and had struggled hard to find marketing reasons why Xerox should use it (this was my "Polish Calvary" experience).

Finally I left.

But what I soon discovered was that it was not my last good idea—and that there were other places where the sword of my mind was valued. I joined Interval Research, where we were challenged to "do the next thing."

The lesson is that, like Kurasowa's wandering ronin Sanjuro, you can leave town, and it's OK to do that. It's important to be passionate about your work, and be true to yourself—and sometimes the best way to do that is to walk away from an employer. You always have to have a customer for your work—one that values it.

Shoot your own Dog

When Interval Research was founded the original 24 members of the research staff were challenged by David Liddle to "create something as different from the personal computer as it was from the mainframe."

I thought about this, in a structural manner, and concluded that the right way to proceed was by systematically inverting a number of the media theoretic elements of what a personal computer (or workstation) was (circa 1993). Doing structural inversion on these elements, with the added heuristic to design to human qualities and abilities that had been "left out" of the user experience of computer use, led to some interesting contrasts, as shown at right.

I properly noticed that this design exercise, carried through to its logical extreme, results in a crowd of unruly puppies. Since I didn't think Paul Allen wanted Interval Research to be a puppy farm, I backed off a little, and decided to explore building mobile robots that communicated emotionally with people and each

SYSTEMATIC INVERSION: AN EXAMPLE

WORK STATION MODEL:	INVERSION:
• Communicates to people via a two-and-a-half dimensional grid of semantic relations (i.e., the desktop metaphor).	• Communicate emotionally–facial expressions, affective sound, bodily gestures.
• Has a paucity of input senses–a keyboard and mouse.	• Use multiple sensory modalities that are shared by humans–including vision, touch and hearing.
• Is fixed in space–it sits on a desk.	• Make something that can move around independently.
• Constrains the body of the user to a cramped posture and limited set of gestures.	• Have it move/experience/act through the same physical and social spaces as people do.
• There is one workstation per user.	• Make lots of them–and have them exhibit flocking behavior.

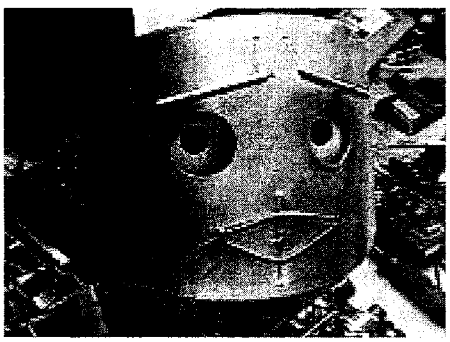
other, and which existed in the same realm of the senses as people did. This was my entry into what is now known as affective computing.

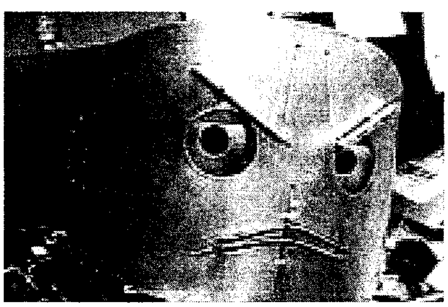
I argued against simulation of such, because people would inevitably react differently to something on a screen than they would to an entity with a body in space. Building real physical robots was therefore essential in order to create a joined system where people were the environment for the robots and vice versa, and where we could ask such questions of people as, "What is the robot feeling?"

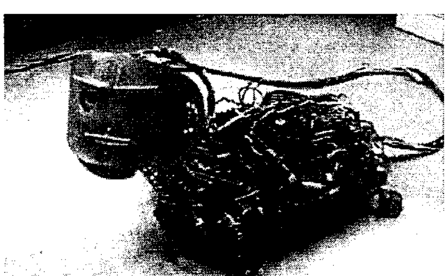
When the project was started, it was in uncharted territory; no one else was doing anything similar. The patent search for the background intellectual property uncovered only a few remotely relevant pieces of intellectual property—a flocking patent, a game patent, and a few others.

My grand strategic goal for the project was to make a strong design statement that would produce design heuristics that others could emulate. Such a strong design statement could be subsequently relaxed from its initial purity of expression to find use in other areas, such as adding affective communication into workstations—in other words, one would not have to always make a full-up robot to take advantage of the understandings produced by first building an emotionally communicating robot.

We started by identifying what were the minimal elements needed to make a face that people would experience as having expressive emotions. We decided not attempt realism, but to aim for what amounted to a line drawing in aluminum and steel. Mark Scheeff built what we called the Mark One "Severed Head"—a cube with six degrees of freedom for two lips, eyes, and eyelids, each driven by computer controlled servos. The Interval "Aquarium" staff (our experimental psychologists) did user testing with naïve subjects who were directed to use a computer keyboard to drive the face to achieve various emotions—happy, sad, angry, afraid, etc. A surprise occurred when we observed the test subjects miming the facial expressions they created on the robot's face with their own faces! We used the resulting settings for the servos to build a database of emotional control points.







Top: John Pinto in the Interval "Aquarium" user research lab controlling the Mark One "Severed Head."
Second: "Shy" robot.
Third: "Angry" robot.
Fourth: Robot, with skin removed.

Then we proceeded to build a full-up robot.The end result, four years later, was a prototype robot that had an expressive face; a mobile body with a articulated neck and head; gestures that emulated the ballistic motions of animal gestures; a sense of touch that differentiated between a caress, a light contact, and a blow (using sub-modalities of an accelerometer and a capacitive sensor); stereo color vision that located peoples bodies in space and tracked them via 3D blob analysis; a voice that could be expressively gendered male or female—and implemented an internal emotional state machine that emulated the seven basic expressive emotions described by Charles Darwin in *The Expression of the Emotions in Man and Animals* [1872].

By 1998 others had started to work in the same general area. Some of these poured far more resources into their engineering—notably Sony with the "Aibo" robotic dog. In the annual project review I argued that we should either spin the project out of Interval as a development effort aimed at real products in the toy market with enough resources to succeed, or we should kill the project. In the end, I killed my own dog—the project was ended.

Mark Scheeff, the member of the research staff who did the mechanical design for the robot, followed on with a six-month "cremator project." He ripped all of the AI out of the system and turned the robot into a tele-operated puppet. His goal was to explore what people perceived about the robot without knowing what it was "under the hood"—i.e., what they projected onto the media surface. He exhibited it at the Tech Museum in San Jose, and members of the project under his leadership published a paper summarizing the results from this exploration of projective intelligence [Scheeff et al. 2000].

The other tangible result from the project was a very broad patent (and a subsequent improvement patent with the same title) covering emotional communication of real, embodied robots with each other and with people, where the major prior art cited was Charles Darwin [Tow 1998].

The lesson from this is don't be afraid to shoot your own dog, if that's the right thing to do. A failed project can be a research success—its influence on inventors and designer can long outlive its original context.

The Wandering Ronin School of Research

sharp sword for hire
jobs behind, and jobs ahead
the ronin walks on