S
E E
K I N G
T H E C I T Y

V I S I O N A R I E S
O N T H E M A R G I N S

9 6 T H A C S A A N N U A L M E E T I N G

DIETMAR FROEHLICH + MICHAELE PRIDE, EDITORS

A C S A P R E S S
WASHINGTON, DC

Published by the ACSA Press and distributed by the
Association of Collegiate Schools of Architecture
1735 New York Avenue, NW
Washington, DC 20006
Tel: 202/785-2324
Fax: 202/628-0448
Web: www.acsa-arch.org

Visionary Education for Tomorrow

Topic Chair
J. KENT FITZSIMONS, *Rice University*

Back to the Future: Three Educational Experiments in Interactive Environments Anticipated in 1960s Visionary Thinking

KEITH EVAN GREEN
Clemson University

Recent advances in Intelligent Systems have made something of the visionary architecture of the 1960s realizable today. Intelligent Systems are those that gather information from the environment, act in response to this information, and learn from this gathering-actuating process to better perform. Intelligent Systems include computer software programs, sensors, motors, and movable components – any element of Information Technology (refereed to here as "IT") which has the capacity to read or react precisely to given information about the environment. Embedded in architectural works at various scales, Intelligent Systems allow architecture to become "interactive" – a quality ascribed to artistic works in seminal philosophical works of the 1960s like Umberto Eco's *The Open Work* and Roland Barthes' *Death of the Author.*

In the same historical period, architects Piano and Rogers strained to extend this interactive quality, with critical compromises, to their design for the Centre Pompidou in Paris. Meanwhile, in the research lab, M.I.T.'s Nicholas Negroponte and his *Architecture Machine Group* investigated "ecosystems capable of intelligent responses…. Buildings that can grow and upgrade themselves, that open like flowers in fine weather and clamp down before the storm; that seek to delight as well as serve you."[1] The architectural visions of Piano and Rogers and Negroponte might be considered examples of the technological "plane" philosophers Deleuze and Guattari define as…

> …not simply made of formed substances, aluminum, plastic, electric wire, etc., nor of organizing forms, program, prototypes, etc., but of a totality (ensemble) of unformed matters which present no more than degrees of intensity … and diagrammatic functions which only present differential equations.[2]

Intelligent Systems, an advanced and increasingly accessible means for rendering architecture a "technological plane" today, affords new possibilities for living in environments rendered interactive. Recent advances in Intelligent Systems research and, the increasing accessibility of powerful IT tools, afford the realization of prototype architectural designs characterized by Eco's "Openness" and suggestive of Archigram's visions of a robotic architecture. Dynamic time-based reconfigurations of the physical environment afforded by information exchange are not only feasible now but are becoming an important way in which architects conceptualize the built environment.

Beginning in the 1980s, computer scientist Mark Weiser, then of Xerox PARC, introduced a new perspective on responsive environments, investigating how IT can be embedded in our surroundings. What has become a field of its own, "Ubiquitous Computing" was Weiser's term for environments made responsive to inhabitants and their situations by means of embedded IT.[3] Weiser envisioned "hundreds of computers per room"[4] all of these physically small and woven "into the fabric of everyday life until they are indistinguishable from it."[5]

More recently, architectural researchers William Mitchell and Malcolm McCullough have investigated responsive, intelligent environments: architectural works of embedded computer hardware and software which actively respond to local conditions as if they were living entities. Embedded IT, notably multiple computers and sensors, allow architectural works to sense the presence and behavior of inhabitants and the presence and movement of virtual and real objects, resulting in responses and accommodations to local, dynamic conditions in support of human needs and wants. Mitchell envisions architecture as "less like protozoa – static, non responsive – and more like us. We will continually interact with them, and increasingly think of them as robots for living in."[6] Individually, Mitchell and McCullough propose the embedding of real-time communicative sensors and actuators in architecture as a powerful means to forward the performance capacity, more than the aesthetic capacity, of architecture. Architecture no longer needs to express the aesthetics of the machine, as prevalent in so much of 20th-century architecture; instead, architecture becomes interactive.

THREE EXPERIMENTS IN ARCHITECTURAL EDUCATION ANTICIPATED IN THE VISIONARY 1960S

Architectural works employing embedded IT are today exemplified by multiple, interacting elements rather than on static forms preconceived by the designer. Two currents in the application of Intelligent Systems to architecture are: (1.) the expanding use of embedded computer displays and projections, and (2.) the emerging instances of a robotic architecture where physical mass, rather than digital bits, are subjected to movement and reconfiguration. Embedded computer displays can be found, for instance, in the building skin of the Kunsthaus in Graz, Austria designed by Peter Cook, formerly of Archigram, as well as in an array of works by Usman Haque; robotic works of architecture include dECOi's robotic, interactive *Aegis Hyposurface* wall, and the *Muscle Body*, a responsive environment comprised of computer-controlled bladders, developed by Kas Oosterhuis' *Hyperbody Research Group*.[7]

This later prospect – a robotic architecture – has been the particular focus of applied design- research investigations undertaken by the author and his students working in collaboration with colleagues and their students from Electrical and Computing Engineering, Human Factors Psychology, and Sociology. A robotic architecture, as Oosterhuis explains, exhibits the capacity to "re-configure itself and produce complexity and unpredictability in real time."[8] Such architecture has the potential to alter the course of architecture and architectural education by placing in motion, figuratively and literally, the very stability of architecture. The architect of such architecture is not the sole master of it but, here, a member of a transdisciplinary team, following more the working paradigm of engineering and scientific research than that of the "genius-architect." This re-conceptualization of the role of the architect and the definition of architecture is compelled, today, by the complex concerns of living in an increasingly digital society.

Bill Gates, in a recent *Scientific American*, recognizes robotics as the next revolution in computing, promising that "robotic devices will become a nearly ubiquitous part of our day-to-day lives."[9] "The PC will get up from the desktop," writes Gates, "and allow us to see, hear, touch and manipulate objects…."[10] The resulting work becomes less a "pure" work of design and more a strange hybrid of design and other concerns, guided partly by the architect. But what does this architecture look like? How does it behave? How does one teach it? And, is it faithful to the visionary thinking that pre-dated it? The author has begun exploring these questions through three "visionary" educational experiments described here.

EXPERIMENT-1: AN ARCHITECTURE STUDIO WITH A ROBOTICS COURSE

In this first educational experiment, the author and his students in a first-year M.Arch. design studio at Clemson University, combined with Professor Ian Walker and his first-year Masters students from Electrical and Computer Engineering [ECE] to "give form" to working life in a digital society. The program was a live-work building that suited an empty tract of land located a short walk from downtown Greenville, South Carolina. Greenville is recognized as a North American focus of international industries (BWM, Michelin, Hitachi, …); it therefore served as an appropriate site for Architecture and ECE student to, in words, make the "information highway" visible.

The architecture students were asked to "give form" to working life in a digital society at various scales, from the scale of a significant architectural element to that of the city. At the scale of the city, the various building proposals were assembled into an urban design "network" which effectively linked downtown Greenville to the established urban residential neighborhood lying a walking-distance to the North.

On the scale of the architectural element, students in the architecture studio were matched with students enrolled in ECE 655: "An Introduction to Robot Manipulators." Taken by incoming graduate students in the robotics area, ECE 655 examines robot manipulator systems and their interaction with people to forward social needs and ambitions. Collaborating at the same level of education, the Architecture and ECE students questioned the traditional envelope of what architects and electrical and computer engineers do. The results were fascinating: student collaborations resulted in proposals that were neither architecture nor engineering but (in many cases) a compelling hybrid of both. This was evident, for instance, in the proposal of a robotic stair [figure 1] designed by Joe Lutz (Architecture) and Ravi Singapogu (ECE), which can be programmed to assume various configurations, providing not only vertical circulation through the building but also informal and stadium seating, work surfaces, meeting tables and storage. (Required egress was satisfied elsewhere in the building.)

This experiment in collaborative education aimed to realize architectural works that were not sculptural but instead interactive. Purposefully, the author set this course for the studio to clash with the architectural current of form-giving (regrettably, in the most superficial sense), encouraging students to explore aspects of architecture beyond the exterior shape and skin of a building. More than creating a novel form, the students were asked to "give form" to different ways of living.

Intellectually, this first experiment in collaborative education showed a new prospect in both Architecture and Computer Engineering by defining the "robot as a room" and the "room as a robot." Redefining what constitutes Architecture, Robotics and Information Technology (IT) is not only a conceptual leap in these three disciplines, but a fully appropriate, even necessary response to conditions in working life that are both technological and social. In this way, the experiment might be characterized as "visionary" not only for Architecture and Robotics but also for Sociology and Psychology, given its reconsideration of workers and the workplace.

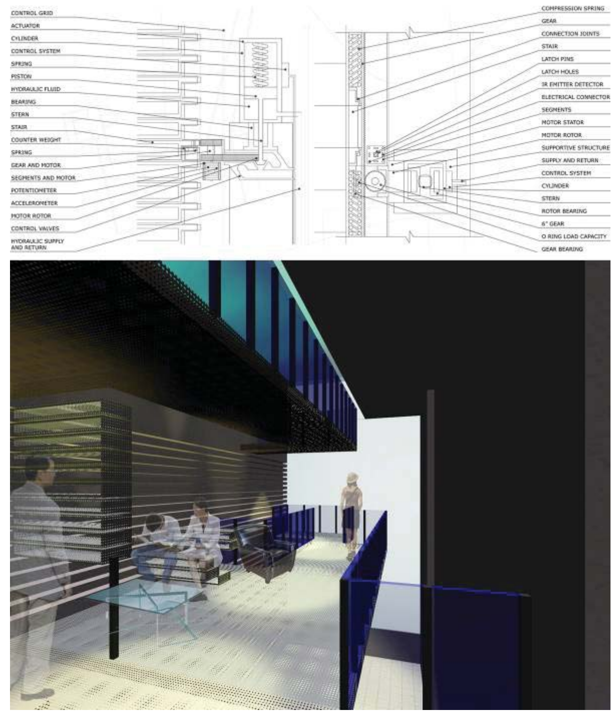

Figure 1: "Stepped Dynamics," a live-work unit for a digital society. Technical drawing and interior perspective of the robotic stair by Masters students Joe Lutz (Architecture) and Ravi Singapogu (Electrical and Computing Engineering) showing a programmable configuration offering seating, work-surfaces, and storage (Author).

EXPERIMENT-2: TRANSDISCIPLINARY POST-GRADUATE RESEARCH

The collaboration considered in the previous section ran in tandem with a major, sponsored research project – the *Animated Work Environment* ["AWE"] The AWE team draws together the knowledge of its represented disciplines to identify new possibilities for the interaction of people and architecture. Broadly, the research investigates how IT might be integrated with architecture to create responsive, programmable environments. Specifically, the research supports working life in a digital society through the design, prototyping and evaluation of a robotic work environment: an intelligent "robot-room" at the scale of a large cubicle. The programmable AWE is capable of being reconfigured and, within prescribed limits, is envisioned to reconfigure itself in response to the needs of individuals and teams of workers.

While AWE is foremost a research project, to date it has engaged and funded five graduate *Figure*

2: Animated Work Environment [AWE], a section, an elevation and a rendering showing a configuration conducive to collaborating, composing and viewing. (Author).

(Masters and Doctoral) research students drawn from all four represented disciplines, as well as four M.Arch. students and several undergraduates from Engineering. The research students, including one architect pursuing a Ph.D. in Environmental Design and Planning (and supervised by the author), use the project as the focus of their theses. Weekly meetings of the AWE research team assess and plan student and faculty engagement in the project, and the four faculty members supervise participating graduate students of their own departments.

This "hands-on" collaborative experiment in postgraduate education is a way forward for all participating disciplines. So while Donald Norman, author of *Emotional Design*, declares the "future of design … [is] that of smart, intelligent devices," he then adds, but "where is one to gain skills in all of these areas? Within the university, each component is a separate discipline, sometimes not even on speaking terms with the others."[11] The AWE experiment provides an answer: faculty and students here collaborate together from appropriate disciplines to respond to the complex problems of living. In short, the answer to Norman's "Where?" is – at least in small part – us.

Figure 2: undertaken by the author, Ian Walker, their colleagues in Sociology and Psychology, and their respective students.

AWE is a workspace composed of a multi-panel, modular, articulated structure [figure 3] capable of folding and reconfiguring its surface as well as accommodating plug-n-play ensembles of peripherals to match the needs and wants of different users. AWE allows users to alter their work experiences by redefining the physical environment. The movement of the surface is made by way of eight panels hinging by means of eight electric motors. When activated, the actuators move one or more of the eight panels to create spatial configurations accommodating different group activities.

Six major spatial configurations are programmed for AWE, each supporting an array of activities that might be described as "Collaborating," "Composing," "Conference," "Gaming," "Lounging," "Playing," "Presenting" and "Viewing"; however, the six configurations are not designed exclusively for any one of these activities but instead "suggest" to users a manner of working and playing that users define for themselves. Furthering this degree of freedom, users can "fine-tune" each of the six standard configurations by operating touch sensors to accommodate particular needs and wants. The novel configurations resulting from such fine-tuning can then be saved and later recalled by users under file names which they define.

Soon to be explored in this research is the incorporation of intelligence where the users' activities are sensed by AWE and AWE responds by reconfiguring itself. For instance, if a person positions herself in front of AWE's panels in preparation for a presentation, and if an audience seats itself to receive the presentation in the same time-span, the presenter and audience can be detected by floor sensors, thereby intelligently reconfiguring AWE to a configuration conducive to presentations. (Again, in respect to users' needs and wants, the individual users would decide for themselves whether to turn "on" or "off" the intelligent behavior offered by AWE.)

Informing the development of AWE from the start, ethnographic research was aimed at identifying workers' practices, needs and wants. Usability testing serves an iterative developmental process of designing, analyzing and redesigning the prototype.

Figure 3: AWE. Developing prototype of the "Robotic Wall" Showing four of its eight panels (Authors).

While the AWE prototype remains at the physical scale of a cubicle, it is not a stretch to imagine this AWE prototype extended to the physical scale of a large room or small building. Using the same specifications for AWE presented here, one can expand the area of each of AWE's panel to a degree, and combine multiple AWE workstations to create a programmable environment at the larger scale of, say, a meeting room, a bar or an information center [figure 4]. Every time one visits such an environment, the sectional condition of the environment could be entirely different, depending on any number of dynamic variables that may include: the number of people present in the environment, the weather, the vehicular traffic immediately outside the environment, and even the dynamic climbing and falling of the stock market. The *AWE* project promises to yield real insights into the potential of a totally responsive robotic-architecture at various scales.

EXPERIMENT-3: AN ARCHITECTURE SEMINAR WITH A HUMAN FACTORS PSYCHOLOGY SEMINAR

In Spring Semester 2007, the author and Psychology Professor Richard Pak invited students enrolled in their respective Masters level seminars to work collaboratively in teams on the design, prototyping and evaluation of what they call "smart boxes." The author's "Animated Architecture" (ARCH 699), focused on design research involving intelligent systems (i.e. intelligent building components and environments); Pak's "Usability Evaluation" (Psych 840) focused on techniques for improving the usability of computer interfaces to various systems. Student teams were required to develop this "hands-on" project involving a number of activities: task analysis, evaluation, cognitive walkthroughs, and rapid prototyping. Student teams also gave digital media presentations of their work and offered and received critiques from the other student team.

The significant assignment for all students, the "smart box" was defined as a physical container which provides an easier way for its users to handle and manage both paper and electronic documents. The premise of the project is that, despite the rapid development of technology over the past several decades, it has become increasingly more difficult and tedious to organize and handle paper documents. The smart box proposals – the "backpack" by one of the two teams serving as example [figure 5] – aim to satisfy the recognized need for a system that will aid the user in this task. While the smart boxes developed and evaluated here were not robotic nor strictly "environmental" in a physical sense, they were design projects with embedded IT motivated by (and potentially integrated with) the AWE project of the preceding section. Students in both teams were required to jointly create a report that (1.) outlined the purpose of the device and described it in detail, including its capabilities and requirements; (2.) elaborated the type of user interface the smart box would require; (3.) detailed user profiles; and (4.) reported the results of an interview with a po-

Figure 4: Animated Work Environment [AWE]. Rendering showing an application of the AWE system comprised of 2 sets of 4 co-joined AWE systems operating together at the scale of a large room (Authors).

tential user and of a task analysis. In addition to this document, the student teams created a "brochure" communicating their concepts.

Bringing together students under these two disciplines produced some compelling and very comprehensive results for student-work at the first-year Masters level. This educational experiment across two graduate seminars generated productive conversations and many terrific ideas and, most significantly, demonstrated the promise of collaborative education and practice.

REDEFINING ARCHITECTURE AND ARCHITECTURAL EDUCATION

The smart boxes, AWE, and the live-work units presented here are three collaborative educational experiments comprised of activities that are somewhat foreign to the architect practicing in the conventional sense. All three projects required the invention of hypothetical "users" or "inhabitants" engaging the design works in real-time "performances." The concepts of the three different IT-embedded design projects were derived from invented scenarios which defined how the architectural works might be engaged by different people under different conditions. At the outset of the AWE project, for instance, the research team invented a group of such users: a biologist named "Laura," her young child, her colleagues, and her nephew visiting from Latin America. The members of this invented group of users were then imagined interacting with AWE, individually and in groups, as a vehicle for understanding what AWE might look like and how it might behave in support of human needs and wants. From the outset, the research team was thinking about AWE not as an isolated object but as one aspect of a dynamic, interactive, responsive system that includes AWE's users and the immediate environment.

While it might be said that architects typically consider how users will engage works of their design, there is a fundamental difference in the case of the projects presented here: the student teams are dealing with a responsive system which is actively engaged by and interacting with the user, rather than a building perceived, wrote Walter Benjamin, "much less through rapt attention than by noticing the object in incidental fashion."[12] Unlike a conventional building, the design projects presented here and their intended users are

Figure 5: "Smart Box." One page from a student brochure designed by a team in which Andy Brooks and Gary Brown were the two architecture students (Author).

bound together in a performance "by design." This makes these interactive projects much more like a cell phone or an automobile than a building: a tool that enables the productive and dynamic interaction between people and things in the world.

An interactive architecture must go beyond simplistic formal achievements; it must instead explore ways for improving life, for developing existing places, and for enhancing human interaction. This is not a utopian dream in which technology or architecture transforms completely our everyday reality. Instead, architecture and technology and, here particularly, a robot-architecture must support human activity, respond naturally, and perform according to both our needs and whims. An interactive architecture, when employed, must also complement and redefine our urban living patterns. Answers to life problems and opportunities must not come from a computational or robotic solution itself, but instead through the way these technologies, embedded in architecture, help forward the interaction across people and their surroundings to create places of significance on many levels. For philosopher Andrew Feenberg, "technology is not simply a means but has become an environment, a way of life."[13] Clearly, an interactive architecture is more than an aesthetic search, a stylistic possibility, or a technological quest; it is, instead, all three in support of old and new patterns of human activity.

Towards realizing such an ambition, collaborative teams such as those described here are required. Such collaborative work follows from a basic premise followed by the AWE investigators in concert with the call coming to us from research universities and (to no surprise) the research funding agencies that help support them (e.g. the National Science Foundation and the National Institute of Health): that the complex problems and opportunities for living today warrant investigation by transdisciplinary teams of researchers drawn from different disciplines sufficiently complex in composition to address these problems and opportunities. More than multi-disciplinary teamwork, which merely brings together investigators from various disciplines, "transdisciplinary" teamwork is defined by its members sharing a conceptual framework that integrates and transcends the disciplinary perspectives of individual team members so that each team member develops some reasonable understanding of how the other members, from other disciplines, think and act. The cultivation of a transdisciplinary team takes time: more time than many architects and architectural faculty members have patience for. As well, transdisciplinary projects have relatively long project cycle (e.g. 3yrs) that might prove frustrating to some architects and architectural faculty members who want quicker outcomes from their efforts.

The ambition to realize an interactive architecture presents new and difficult challenges to architectural educators and architecture students. Towards educating a new generation of architects, the author and his faculty collaborators offer studios and seminars which cultivate collaborative activity by running in tandem with classes in different disciplines but at the same educational level to promote knowledge exchange. The author and his collaborators agree that this experiment is robust and scalable, meaning that the design challenges described here are at an appropriate physical scale to guide "real" projects in the field at the same scales, as well as at much larger scales. Whatever the scale, students having engaged in this kind of educational experiment are better prepared to realize architectural works of advanced complexity, realizable today and anticipated in the visionary works of the 1960s.

In a recent *Harvard Design Magazine* article, David Celento argues that architects "invite their extinction" if they fail to "embrace technological innovations"[14] which potentially open new possibilities for architectural practice. The "visionary" educational experiments described here begin to cultivate in architectural students today new vocabularies and new, complex realms of understanding which promise both novel design propositions and the very survival and even flourishing of architectural practice and architecture tomorrow.

ACKNOWLEDGMENTS

Many thanks to colleagues Ian Walker and Richard Pak and my doctoral student Henrique Houayek. Support for AWE comes from the U.S. National Science Foundation, grant number IIS-0534423.

ENDNOTES

1.Nicholas Negroponte, *Soft Architecture Machines,* (Cambridge, MA: The MIT Press, 1975), 129.

2. Gilles Deleuze, Felix Guattari, "Concrete Rules and Abstract Machines," *SubStance*13, No. 3/4, Issue 44-45 (1984): 7-19.

3. Mark Weiser, "Ubiquitous Computing", http://sandbox.xerox.com/ubicomp/.

4. Marc Weiser, "The Computer for the 21st Century," *Scientific American*, September 1991.

5. Ibid.

6. William Mitchell, *E-topia* (Cambridge, MA: The MIT Press, 2000), 59.

7. Kas Oosterhuis "A New Kind of Building," http://www.oosterhuis.nl/quickstart/index.php?id=438.

8. Ibid.

9. Bill Gates, "A Robot in Every Home," *Scientific American*, December 16, 2006, http://scientificamerican.com/article.cfm?articleID=9310D12D-E7F2-99DF-3FA1568DCF374C60.

10. Ibid.

11. Donald A. Norman, "The Next UI Breakthrough, Part 2: Physicality," *Interactions* (July/August 2007): 46-47.

12. Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Art Theory 1900-1990*. (Oxford: Blackwell, 1992), 519.

13. Andrew Feenberg, *Transforming Technology, A critical Theory Revisited* (Oxford: Oxford University Press, 2002), 8.

14. David Celento, "Innovate or Perish, New Technologies and Architecture's Future," *Harvard Design Magazine* (Spring/Summer 2007, Number 27), http://www.gsd.harvard.edu/research/publications/hdm/current/26_Celento.pdf.