QUARTERLY OF THE INDUSTRIAL DESIGNERS SOCIETY OF AMERICA **SUMMER 2015**

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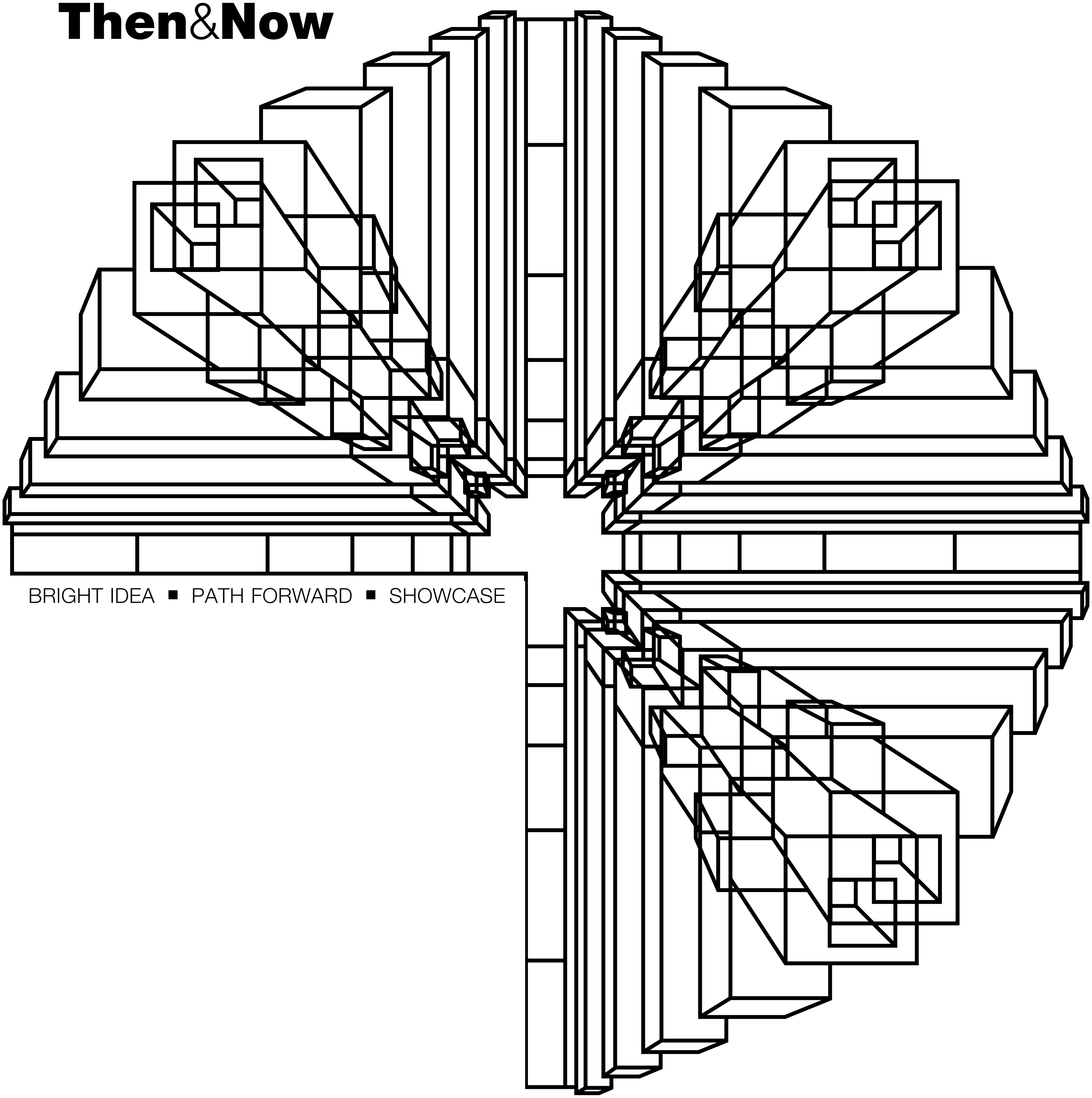

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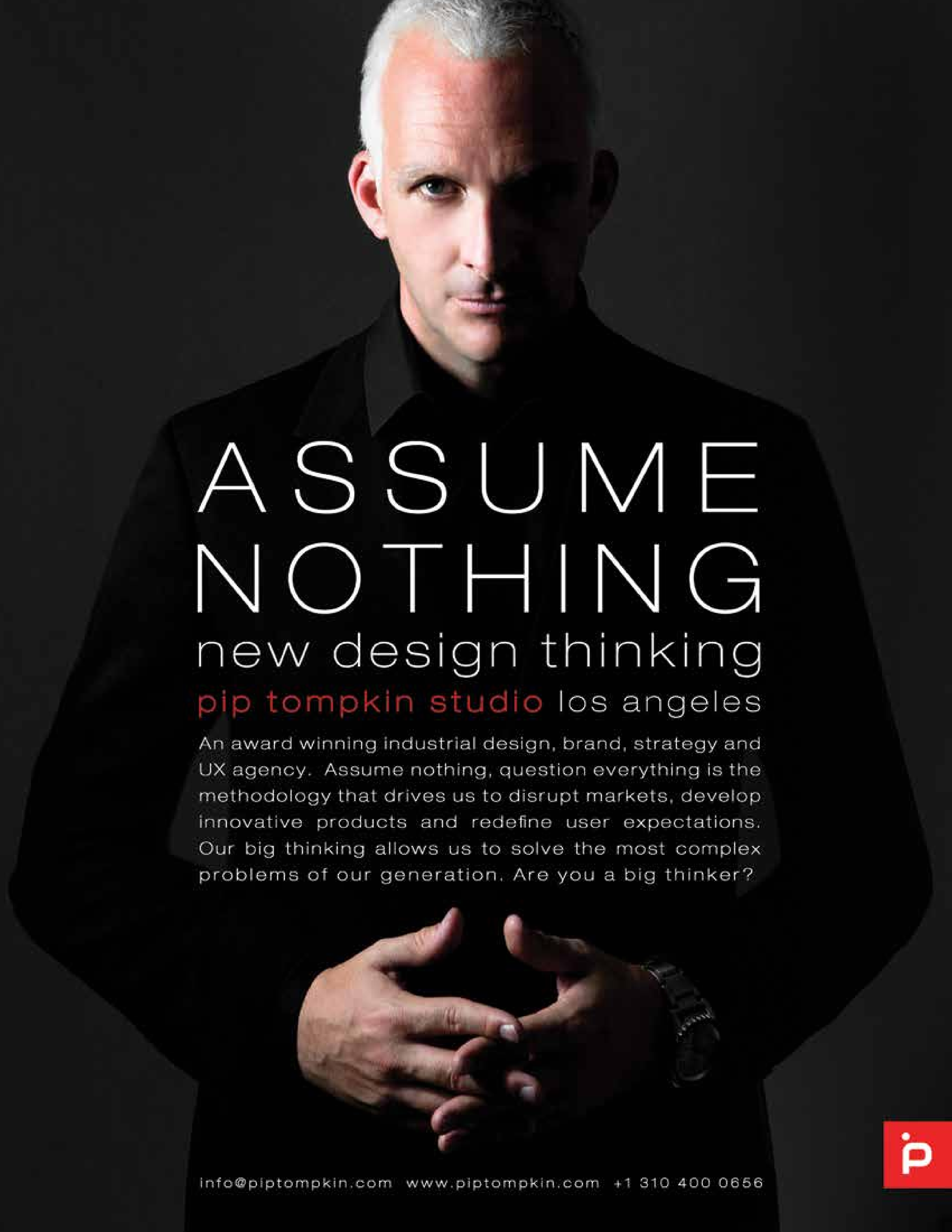
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The quarterly publication of the Industrial Designers Society of America (IDSA), INNOVATION provides in-depth coverage of design issues and long-term trends while communicating the value of design to business and society at large.

THEN & NOW

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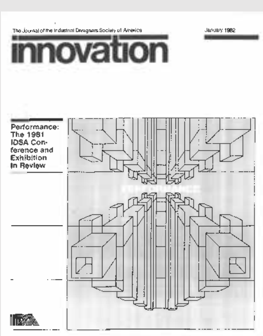
IN EVERY ISSUE



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A Research Project

THE DYNAMICS OF INTERDISCIPLINARY DESIGN

As designers, we know that the nature of our work requires us to appreciate and cooperate with professionals from many different disciplines in order to arrive at the best possible solution. Yet each profession still educates its students in discreet programs with neat and easily managed courses where, for the most part, everyone is learning to do the same thing, the same way, with the same tools. No wonder, then, that when these disciplines need to work together, the process is full of misunderstanding, conflict and disdain for contributions from other disciplines. The result is often frustration, anxiety and anger.

The whole idea of who, how, when and where design is carried out was the subject of many hours of discussion between myself and four colleagues, each from a different design discipline. Together we represented industrial design, mechanical engineering, aerospace engineering, electrical and computer engineering, and industrial operations engineering.

We set out to explore designing, designers and their designs in order to gain insight into how designing is actually carried out and under what circumstances can the three be better understood and refined. To this end, we sought and won support from The National Science Foundation for an interdisciplinary research project to observe and learn about design processes. The research project stretched over three years and resulted in more than 100 observations on the design process and the interaction of design teams.

The Project's Structure

We invited five students each from our respective disciplines to participate in a two-semester sequence. We divided these 25 students into five teams, placing one person from each discipline on each team. In the first semester, the teams had to develop their design solutions from problem statements through to three-dimensional models. In the second semester, the students had the opportunity to further develop their designs from three-dimensional models to full working prototypes made from actual manufacturing materials and processes. In fact, they were required to use an IBM robot in an adjoining lab for actual robotic fabrication or assembly. In addition, each faculty participant presented three to four lectures to the entire class, thus sharing their respective disciplines' philosophies, methodologies, tools and emphasis.

Although it was a research project, the students were more than experimental subjects. They got to hear new information, including some provocative contradictions. The process itself exposed them to the challenges of collaboration. It also required that they go beyond the paper solutions to a completed prototype, a rare opportunity.

Although our primary interest was with observing the student teams and not with their designs as in traditional design courses, their designs were innovative and professional. Over the three years, student teams designed free standing library book collection stations (1986); fixturing systems for robotic fabrication and assembly (1987); and mechanical devices that emulated the locomotion found in an animal of their choice (1988). We documented all major design presentations on videotape for use in our research, as well as still another tool for the students to use as they refined their presentation skills.

We made hundreds of observations over the three-year period. The following are a few that represent an interesting mix of issues. I should point out that I am not a social scientist, but rather a designer and, therefore, cannot quantify or state that my observations are universal. I simply offer them to you in hope that they generate interesting questions and ideas for you to pursue.

By Allen Samuels, IDSA
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Allen Samuels has been an industrial designer and member of IDSA since 1966. He has maintained a professional practice concurrent with his teaching at the School of Art and Design at the University of Michigan where he was a full professor (1975–2008) and dean (1993–99). In retirement, he continues to design products that deal with aging, disaster relief and concepts that are beyond current technologies. ***Acknowledgment:*** *This project was supported by The National Science Foundation. Faculty participants were: Professors Allen Samuels (Industrial Design); Panos Papalambros (Mechanical Engineering); Joe Eisley (Aerospace Engineering); Lynn Conway (Electrical and Computer Engineering); and Dev Kochar (Industrial and Operations Engineering).*

Observations About Individual Designers

- *Almost all the participating designers felt they were always to be responsible for generating innovative and inventive designs. However, after lengthy discussion, these same designers felt that both as students and as professional designers, innovation and invention represented high risk for themselves and for their companies. They felt a more realistic strategy was for designers and companies to follow the lead of innovative and inventive competitors and to work to emulate their offerings, thus reducing risk for themselves and for their company. Certainly this attitude represents a risk in itself and it may affect our overall ability to be truly competitive in today's highly innovative and inventive global market.*
- *Those designers who were trained on computers only often could not fully appreciate the ramifications of a three-dimensional object as it appeared on a flat two-dimensional computer screen.*
- *Some designers naturally relied on their intuition and then on their knowledge. Others relied on their knowledge and then on their intuition. Some dismissed intuition totally.*
- *Some designers chose to play a minor role on a team. When found out, they were criticized and given low-quality tasks to do. These designers found it all but impossible to regain status.*
- *When individual designers were asked to list their personal values and then describe how their values were expressed through their designs, many could not respond.*
- *Most designers eagerly worked to resolve a given design problem in technical terms, but they often could not address or clearly express the proposed effect of their design on targeted constituents.*
- *Some withheld their concepts during informal concept evaluation sessions, waiting for "Glory Times" when the*

audience would be more receptive, when stakes and rewards would be at their highest, and when attention would be formalized. Unfortunately, the approach often backfired if a concept was faulty.

- *Verbal skills employed forcefully and persistently could convince a team to go with what was sometimes a lesser design proposal.*
- *Engineering students often focused first on functional components when approaching a design problem. Industrial design students were often preoccupied with external form issues. Both groups saw the other as seeing the "wrong" issues and depended on the other to solve whatever problem the other left behind, be it external form or internal realities. Their collective behavior reflected their discipline-specific orientation and bias.*

Observations About Team Interaction

- *The ideal team size was around five. Uneven numbers eliminated the possibility of a tie, forcing teams to resolve conflicts. Teams with fewer members often lacked the ability to do a great number of tasks at any one time.*
- *Personalities, sexual mix, nationalities and age differences were some factors that could undermine a team's performance.*
- *Some teams used a "core" team around which other individuals were added or eliminated as required. More flexible, it was also more difficult to manage.*
- *Early in a team's life, leadership often changed from one individual to another based on an individual's overall intelligence, capability, experience, verbal skills and personality. Often the person perceived as the most capable became the team leader, yet the most capable persons were not always the best leaders.*
- *Because team leaders also participated as designers, separating authority from equal contribution was not always simple. A leader's concepts were not to receive special consideration, causing some leaders to inflate or deflate the value of their ideas in order to be seen as fair.*
- *When a team leader was successful, a team's expectations often rose. When leaders realized this, they were sometimes intimidated by their own power and would work to limit or control the team's project and expectations. Objectives were then modified so as not to overchallenge the team and threaten the team's chances for success.*
- *Highly confident leaders often shared leadership, letting it change hands depending on who had the particular skills needed during particular project phases or tasks.*
- *Some teams broke major projects down into subprojects with each one led by a different member. This scheme gave everyone a richer educational experience.*
- *Not all teams had a leader to whom everyone reported, yet in those teams where all members were equal, informal leaders arose as necessity demanded. The quality of work produced in both situations did not seem to be affected by the organizational setup alone. Unofficial leaders led based on their capabilities during a particular project phase where their expertise was determined to be superior.*
- *Democracy in those teams where individuals were to be equal did cause decision-making problems. An individual who did not like the mediated conclusion still had an equal right to not cooperate.*
- *Some designers minimized project and problem variables while others extended them. When a team had both types on it, they could seriously disrupt work.*

Observations About the Design & Development Process

- *Generating a sound problem statement and then formulating an appropriate design methodology was usually seen as a chore, if seen at all. They wanted to design products and vested all their creativity here. Many designers never assumed responsibility for formulating or questioning a problem statement.*
- *Each team member interpreted a given problem statement differently. Often, instead of capitalizing on the differences and expanding the problem scope, teams worked to summarize and thus limit the project scope, trading breadth for consensus and ease of management.*
- *Long-term projects were often structured into understandable mini-projects and phases, which made them seem more reasonable. Achievable sub-tasks provided valuable performance evaluation benchmarks that helped teams keep sight of their project objectives.*
- *Quality results did not correlate with intelligent, well-ordered and articulate design methodologies, necessarily. Sloppy habits sometimes produced excellent results, although there tended to be better results from those using better methods.*
- *Project planning seldom accounted for inevitable failures, false starts, second and third tries, and surprises.*
- *When project leaders managed a work sequence, including goal identification-action-evaluation and reward, it improved motivation, maintained project momentum and gave long-term projects needed benchmarks.*

Observations About Concept Generation

- *As each team member produced concepts, so did each team member have to act on all of the concepts put forth. This motivated them to invest in every concept and tended to ensure every concept a full hearing, discouraging the "mine/yours" problem.*
- *Designers behaved differently in different stages of the project, reflecting a sense that early conceptualization and research were open and exciting, and that detailing and final design work were serious and restrictive work. The early high levels of enthusiasm and open inquiry declined once a design was being detailed.*
- *Designers were quick to eliminate concepts prematurely and generate additional concepts when any flaw was identified. Seldom would they correct the perceived flaw.*

- *Individuals and teams producing large quantities of concepts often generated more exciting and original concepts than individuals and teams that produced few options.*
- *Concepts visualized on paper were considered less valuable than when visualized on a computer.*
- *Some designers first wrote a list of criteria to help them generate concepts. Others used their generation of concepts as a means of questioning and identifying sound product and project criteria. They then conceptualized again in order to formulate viable design concepts. The latter approach seemed to provide better design criteria and initial concepts.*
- *Some designers attacked a design problem directly by dealing first and almost exclusively with the technical aspects of the device. The history, context, environment, form, competitiveness, cultural, legal and other issues seemed nonexistent and were, in fact, often excluded in design considerations. Most design education seems to deal with "how" and not with "why."*
- *Some designers initiated their designing by first identifying what technical components were required within a functional device. They then worked to develop concepts around these components. Other designers developed generalized concepts and after identifying the most promising concepts, they then specified the components that would provide the required functions.*

Observations About the Evaluation & Selection of Concepts

- *Teams found criteria more useful when ranked as absolute, negotiable, marginal and optional. They often found agreeing on the actual ranking, however, a very difficult task.*
- *The teams found that risks associated with various concepts could be better appreciated and managed if each concept was placed under categories such as low, moderate or high risk. However, risk was seen differently by each participating designer.*
- *Every constituency had their own hierarchy of benefits and risks and therefore the trade-offs they were willing to make were often different one from another.*
- *Many interesting design concepts were dropped because the design tools being employed by the designers could not support or help the designers clarify and develop the concept. The fault lay with the designers and their choice of tools and not necessarily with the original concept.*
- *Simple and direct solutions to problems were often seen as too easy and less than valuable. Low tech was often devalued and only complicated solutions were seen as satisfying and professional.*
- *The designers defined good designs broadly as those that satisfied a given people, their purpose, place and time. They tended to consider some "World" products faulty, even irresponsible, yet they recognized that the pressures of international marketing require simple and generalized design responses. They wrestled with this dichotomy.*
- *Cost and price considerations were always significant criteria against which every design was measured. The relationship between price and value, however, was more difficult to reconcile.*
- *When a concept was considered too costly, the team often dropped it, failing to reconsider it in terms of cost reduction or adding value to justify higher costs.*
- *During a project, if new and "friendly" information was found that would influence the design in positive ways, it was often easily incorporated into the project. If "unfriendly," the information was often ignored.*
- *Evaluative criteria were sometimes custom made to fit the concepts. Criteria were often altered by designers, but seldom to further constrain the design problem.*
- *When a problem could not be easily solved, for any number of reasons (lack of time, resources, expertise, etc.), designers had few qualms about changing the problem to better suit their capabilities and resources.*
- *Highly motivated and enthusiastic individuals and teams sometimes had difficulty evaluating their work objectively. Enthusiasm and team spirit, at times, blinded their ability to identify strong concepts from weak ones.*
- *Words and phrases (sky blue, constraints, wild idea, conceptual, intuitive, notion, visualize, off the wall) often influenced the value of what was being heard.*
- *Those who could draw and illustrate an idea clearly were sometimes appointed to this task primarily—they became visual secretaries for other team members who could not document an idea.*
- *At design presentations, designers who provided specific comments aimed directly at each constituent's typical concerns, recognizing the various points of view, had their design concepts more readily accepted.*
- *Excellent concepts were sometimes deemed undervalued because the evaluator lacked the relevant knowledge and experience.*
- *During concept evaluation sessions, there were always those who offered still more concepts rather than constructive criticism. They saw evaluation and conceptualization as the same thing.*

Observations About the Development Phase

- *The idea that a designed object can, through its form, express important information to the end user was foreign to all but the industrial designers. The use of nonverbal and visual design cues as a means to communicate utility, complexity, orientation, control, motion, human factors, value and other issues was seen as a vague and almost mystical concept.*
- *Unlike facts, intuition, notions, senses and feelings left designers anxious and uneasy.*
- *Some designers adhered to their initial problem statement and would not consider modifying it no matter what new information was discovered. The farther into the project, the less flexible the designers became and the more unwelcome new information was.*

- *Halfway through a project, designers were often irritable, tired, bored, vulnerable and discouraged. Toward project end, spirits and attitudes would pick up, almost matching the levels at project initiation.*
- *Robotic fabrication, robotic assembly and flexible factory opportunities create limitations and opportunities that affect the design of mass-produced objects. Often, such implementation, manufacturing, assembly and testing issues were not dealt with until a design was being finalized. Designers considered the idea of including such considerations early on in design conceptualization as stifling creativity.*
- *The cost/price equation was considered important to designers and those business persons consulted from outside of the class. Cost restraints were respected by both groups. However, seldom were "added value" arguments put forth. If and when they were, they were very difficult to quantify and, thus, often less than convincing.*

Observations About Design Environments & Tools

- *Physical spaces are required for individuals to work alone, to work in small team groups and for meetings of larger numbers. Teams required a sense of their own secured space with their own tools in place.*
- *Tools that enabled group interaction were used most frequently, ranging from a low-tech erasable board mounted to a wall to a high-tech experimental environment that provided individual keyboards and video screens and a large common computer screen on which whole groups of people could interact. They also used paper and pencil, computer and various software programs, mathematical modeling, finite element analysis, words and word chains, matrices, and various two- and three-dimensional sketch model-making materials and techniques.*
- *The designers were comfortable with the tools of their discipline but carefully tried the tools that were new to them. When left to themselves, however, most used only the tools they were most familiar with.*
- *Round tables seemed to promote more equal participation as opposed to rectangular ones. Rectangular tables almost always provoked a comment about the person who sat at the head of the table, criticizing them for presuming a leadership role.*
- *The participants saw drawing as a "trivial" skill; however, those designers who could draw well were often able to convince others of the merits of their design proposal. Often the value of a design was established by the quality of the drawing.*
- *Computers quickly presented many decisions for the designer to make. It also forced designers to make decisions so fast that often they lacked the time to give reasonable consideration to the issues involved.*
- *Because two-dimensional tools were often used to solve three-dimensional questions and issues, component fit, fastening, component interference, scale, motion and other design details turned out to be inaccurate or impossible when ultimately modeled in three dimensions.*
- *Rapid prototyping was carried out in part on a computer -driven mill. The ability to quickly generate a design on the video screen and then have the mill produce the part was very helpful in saving time as the need for drawing production was eliminated. Because it was relatively easy to do and because some designers were weak at translating from two to three dimensions, the computer-mill was used to make many trial parts.*
- *Making many trial parts often with trivial changes took away the time advantage gained by having such a tool. This capability could not, in itself, make up for the lack of two- to three-dimensional translation experience.*

Ramifications for Design & Design Education

This research made clear that in today's educational institutions we fail to prepare designers of all kinds for multidisciplinary collaboration. Our graduates may welcome the spirit of the idea, but they have no idea how to initiate or manage productive collaboration. Instead, designers are taught discipline-specific methodologies, tools and skills. It should be no surprise, then, that they bring discipline-specific biases to projects, biases that often block logical attempts at collaboration. In short, we teach designers how not to hear and work with others.

Design education is still traditional in its approach, philosophies, tools, content and breadth. New ideas and techniques are difficult to include in traditional educational programs. When new ideas are included, often the old ideas are dropped and not blended with the new.

The most significant results of our experiment were the few insights that may help us see and understand a bit more about the activity called designing. For example, we learned that we know very little about how designing is carried out, both by individuals and teams. We declare that collaboration is crucial, yet few know much about how to structure and evaluate a successful collaboration. We learned that there are many who call themselves designers who see designing very differently in terms of objectives, scope, methodology, tools, environments and expected yield. We learned that design research is an opportunity waiting to be explored and yet few design education programs carry out research about design process. We saw little sensitivity to the human being who would use the design, but a lot of interest in the technology of achieving the design. Often, results were in fact valueless, superficial and hollow technological configurations with little significant purpose, place or value.

We also discovered that there is much we can do to identify and develop our knowledge about designers, designing and designs. As design educators, we can carry out additional experimental and cross-disciplinary courses. As design practitioners, we can reconsider not only how we design but why we design. And as end users of designs, we can be more thoughtful and demanding as we determine what we will live with and what we will not accept.

Multidisciplinary Design, 27 Years Later

When I wrote the original article, I was still a professor of art and design in the School of Art and Design at the University of Michigan. The series of special sponsored courses described in it were among the best teaching experiences of my career because each time we provided this multidisciplinary experience to our multidisciplinary group of students we all (faculty and students) learned much more than just how to design, develop and prototype an original design.

We were immersed in individual and team dynamics and all the challenges that come from bringing people from various disciplines together to work on a team. This, of course, was our purpose. Although the courses were titled *An Advanced Design Lab*, where students designed and fabricated prototypes solving challenging problems we faculty generated, the real purpose of the courses was to observe and gain insights into individual and team dynamics, collaboration and team management across mixes of disciplines that included industrial design, mechanical engineering, business, architecture, and computer and industrial engineering. Throughout the courses we observed and noted the dynamics of how individuals and teams work. We especially wanted to identify the nuances of and obstacles to teamwork, creativity and design methodologies.

Now that I am retired and it has been some years since I taught the courses, as I read my original article I found that much of what I observed still holds up. I think that today more professionals understand the benefits of having multidisciplinary teams; however, people in mixed teams continue to find it difficult to work together in professional practice.

Individuals from different disciplines still do not necessarily share definitions of common words and activities such as research, conceptualization, visualization, modeling, form, function and aesthetics. Each discipline brings a different sense of identifying objectives, timing and methodology while working through a problem. Visualization skills and experience with various design tools and three dimensions in real time and in real life are not easily shared and understood by everyone. The measure of scale, value, aesthetics, ergonomics and complexity also continue to be considered differently.

Solving challenging problems and designing a device, it turned out, was easier for our students and faculty than working in a team where each member represented a different discipline and each was convinced that their way of working was *the* best way of working. Even though more companies today understand the benefits of multidisciplinary teamwork and breaking down traditional departmental boundaries, such work still creates team and project management challenges. The companies that continue to push a project through from one department to another and another in series until a design or product is completed pay a different price for piecemeal design.

Design tools and technologies certainly have changed since my original article, but human dynamics still are the key to any creative enterprise. As long as universities continue to maintain those traditional barriers and boundaries around each discipline and produce rather myopic graduates who have not benefitted from multidisciplinary thinking, experiences, courses and methodologies, problems will result when these people meet one another to work in professional settings. They will find that the world does not rotate around them and their particular way of seeing, thinking and working.

I am proud to say that when I was still teaching at the university, as a result of the Advanced Design Lab, I developed and put into place a dual degree program that enabled undergraduates to earn two degrees in five years: a BFA (industrial design) and a BS (mechanical engineering). The idea was to provide students the best of both engineering and design methodologies and tools and thus produce a more open minded and creative "designer."

In summary, as long as we still educate our students within traditional disciplines with traditional boundaries, workers will be challenged when they are in professional settings and find themselves surrounded by and teamed with others who see the world very differently. If only we could prepare them so that when they arrive in the professional world they are experienced, open and eager to expand their way of working as part of a divergent team of individuals who are each able to contribute and to enhance one another resulting in enriched work experiences and extraordinary end products. ■


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