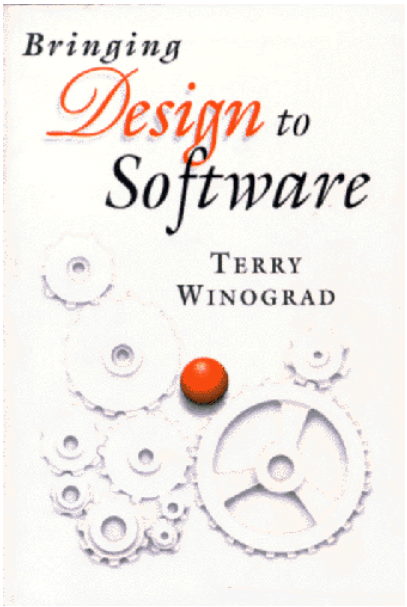

Bringing Design to Software

9
Reflective Conversation with Materials
An interview with Donald Schön by John Bennett

There is no direct path between the designer's intention and the outcome. As you work a problem, you are continually in the process of developing a path into it, forming new appreciations and understandings as you make new moves.

Donald Schön has been studying professionals-especially professional designers-for many years. Although his academic home was in a department of urban design, his subjects of interest have ranged from psychiatrists and social workers to architects and jazz musicians. After observing and interviewing practitioners in many domains, Schön was able to characterize the common elements in their practices and their ways of teaching new practitioners. In The Reflective Practitioner (1983) Schön drew on examples from these studies to outline the basics of what it means to have and to apply expertise. In a further book, Educating the Reflective Practitioner (1988), he delved more deeply into the process of teaching design.

Schön discusses the activity of design in this interview by John Bennett, who has worked extensively with user-interface designers during his 30 years with IBM. Bennett's experience in software design serves as a background for bringing out Schön's broader analysis of design and expertise. Schön describes the different stages through which a designer travels, and notes the interplay of reflection in action-the shift that happens when a surprise interrupts the flow of skilled, practiced performance, and the designer shifts to a more conscious mode of analysis. Although software is not Schön's main focus, his observations will be familiar and relevant to practitioners of software design, and will complement the discussion of design as a creative leap by Kelley and Hartfield in Chapter 8.

-Terry Winograd

John L. Bennett: People working in software design may find it instructive to learn what you have observed in other design communities. One of the key issues that you have written about is the kind of reflection that a designer does while designing. Indeed, the phrase reflection in action is identified with your work. Could you say more about it?

Donald A. Schön: We can distinguish reflection in action from everyday action. As we go about everyday life, we all exhibit knowledge in a special way. Although we often cannot say what it is we know, we do know how to take action. We carry out many actions, recognitions, and judgments without thinking about them. In fact, in many cases, we do not even remember how we learned them. Activities as fundamental as walking fall in this category. We could say that our knowing is in our action.

Reflection in action has a different character: It is closely tied to the experience of surprise. Sometimes, we think about what we are doing in the midst of performing an act. When performance leads to surprise-pleasant or unpleasant-the designer may respond by reflection in action: by thinking about what she is doing while doing it, in such a way as to influence further doing. For example, when talented jazz musicians improvise together, they listen to one another and to themselves. Within the structure of

the piece and a familiar harmonic scheme, they think-or perhaps feel-what they are doing. While in the process, they evolve their way of doing it. The players keep on playing while, on occasion, noting and responding to the surprises produced by other players.

In architectural design, the "performer" frequently conducts an experiment in the form of a series of drawings, such as those in Figure 9.1. He sketches, for example, how the forms of a building might be butted into the contours of a site. In this process, he may discover-to his surprise-that the contours work against the building's form In response to this discovery, he may conclude that "the site is screwy," so it requires "imposing a geometry onto the contours." He may then invent such a geometry and overlay it onto his drawing of the contours. He works by drawing, sometimes combined with talking. If he is practiced, he may work smoothly, without stopping. In such an instance, the designer is reflecting in action, both on the phenomena he is representing through his drawing and on his previous way of thinking about the design problem.

>>>>>>INSERT FIGURE 9.1 ABOUT HERE<<<<<<

Figure 9.1 Reflection in Action This series of sketches was developed by an architecture student as she tried to fit a building into the contours of a site. The process was an interactive cycle of sketching and then using the sketch to reveal implications for the design. (Source: Adapted by permission from Donald A. Schön. Educating the Reflective Practitioner. San Francisco: Jossey-Bass, 1988, p. 51.)

In some design situations, on the other hand, the designer responds to surprise by executing what the philosopher Hannah Arendt has called a stop and think. Here, the designer exhibits a reflection on action, pausing to think back over what she has done in a project, exploring the understanding that she has brought to the handling of the task. She may, for example, construct a new theory of the case, reframing the problematic design situation in such a way as to redefine, interactively, both means and ends.

In a third kind of reflection, reflection on practice, the designer may surface and may criticize tacit understandings that have grown up around repetitive experiences of designing. For example, he may become aware of having fallen into an unfortunate pattern of design behavior, such as "falling in love with an initial design idea," or "trying to build the diagram."

JLB: Reflection seems to be a critical aspect of design. Are there other aspects that help to define design as a process or an activity?

DAS: If you push the question of "What is design?" one of the key issues that you hit on is a particular sense of complexity. The totality of an artifact, system, or situation includes many elements: materials, a sense of purposes and constraints as the designer sees them, and the designer's sense of the people who will eventually use the artifact resulting from the design process.

A designer makes things. Often, the thing initially is a representation, a plan, a program, or an image to be constructed by other people. Many of the relevant variables cannot be represented in a model; this limitation makes the design process inherently complex. A system is complex in the specific sense that, whenever I make a move, I get results that are not just the ones that I intend. That is, I cannot make a move that has only the consequences that I intend. Any move has side effects.

This unpredictability is a central attribute of design-it is not necessarily the defining one, but it is important. It means that there is no direct path between the designer's intention and the outcome.

As you work a problem, you are continually in the process of developing a path into it, forming new appreciations and understandings as you make new moves. The designer evaluates a move by asking a variety of questions, such as "Are the consequences desirable?" "Does the current state of the design conform to implications set up by earlier moves?" "What new problems or potentials have been created?"

Typically, inventions made within a design process to solve present problems produce unanticipated consequences, some of which are perceived as further problems. For example, in the 1950s, product developers at the Gillette Corporation wanted to make their razor blades sharper-perhaps to compete with the newly developed stainless steel blades. They applied a technique of double-honing, which did yield sharper blades. But it had the undesirable side effect of increasing the surface area of the blades, and thereby making them more susceptible to corrosion. The Gillette researchers then found a way of coating the double-honed blades with silicone, which increased corrosion resistance.

Seeing the new problems (and benefits) to which problem-solving moves may lead, the designer may form a deeper understanding of the complex problem space in which he is operating. His new understanding of the complexity of the situation may serve as springboard to a new round of problem-solving inventions.

JLB: In your books, you have also used the phrase a conversation with the materials. Where does that enter into the picture?

DAS: It is rare that the designer has the design all in her head in advance, and then merely translates it. Most of the time, she is in a kind of progressive relationship-as she goes along, she is making judgments. Sometimes, the designer's judgments have the intimacy of a conversational relationship, where she is getting some response back from the medium, she is seeing what is happening-what it is that she has created-and she is making judgments about it at that level.

One form of judgment in which I'm particularly interested is the kind that I call backtalk, where you discover something totally unexpected-"Wow, what was that?" or "I don't understand this," or "This is different from what I thought it would be-but how interesting!" Backtalk can happen when the designer is interacting with the design medium. In this kind of conversation, we see judgments like, "This is clunky; that is not," or "That does not look right to me," or just "This doesn't work." The designer's response may be "This is really puzzling," or "This outcome isn't what I expected-maybe there is something interesting going on here."

JLB: Does a designer ever get this kind of effect from observing how a product of design is used in the field?

DAS: Yes. I once did a study at 3M [Minnesota Mining and Manufacturing], observing how they went about developing new products. Do you know the Scotch Tape story? Scotch Tape was a World War II product, invented by Brandon Cook in the 3M laboratories. He had the idea that you could use transparent cellulose-acetate ribbon, with pressure-sensitive adhesive on it, to mend books. And since you could mend books with it, you wouldn't have to throw the books away, and you could save money; hence, the name Scotch.

When 3M put the product out into the marketplace, it discovered that mending books was not the only use that people had in mind. People did bizarre things with Scotch Tape: they wrapped packages, hung posters on the wall, used it to put their hair up in rollers. And then-I guess this would have been in the late forties-3M began to observe what these consumers were doing, and their staff started rethinking the product in light of what they were getting back.

JLB: So, it was a feedback cycle?

DAS: I would say it was a backtalk cycle, because they were not just being told, "You're steering slightly to the left when you should be moving to the right." They were being told, "This product is not what you think it is." Consumers were projecting onto the product meanings different from the intentions of the product designers. As a result, 3M came out with a hair-setting Scotch Tape, a medical Scotch Tape used for binding splints, a reflective Scotch Tape for roads, and so on. I forget how many new uses there were, but they built on the order of 20 or 30 businesses through the differentiation and

specialization of the basic product idea. They learned what the meaning of the product was by listening to what people said and by observing what people did.

So, if you were asked the question, "How was the invention made?" you would have to answer, "Through a conversation with the users." In this phrase, the term conversation does not denote a literal verbal dialog. Rather, it refers to an interactive communication between designer and users in which the messages sent, received, and interpreted may take the form of words, actions, or objects. In the 3M example, Scotch Tape-both the product and its name-conveyed a message to users about the product's intended function. Consumers received that message and transformed it. The designers, in turn, picked up the new messages that users were sending to them through consumer behavior, reframed the meanings of the product that they had designed, and incorporated those meanings in new variations of the product.

JLB: A different aspect of design-one that is commonly observed in software design-has to do with usability. If software is truly well designed, the details of its operation disappear. We sometimes say that well-designed software is obvious or intuitive. People become aware of bad design in its not working.

DAS: Yes, a good designer strives to make the details work so well that they become invisible to the user.
Michael Polanyi was a physical chemist who became a philosopher. His book The Tacit Dimension (1966) contains an interesting passage on "What is a machine?" His argument is that a machine is an abstract system whose elements are functions, such as the function of the calculator, the function of the spark plug in the automobile engine, the function of the lever, or the function of the spring. The question of the materials used in the composition of the machine is not pertinent, unless a component fails. Then the issue of what the machine is made of becomes important; until that point, unless the machine fails, its composition is not important at all.

Broadly speaking, we might say that an object's failure or difficulty in use makes visible its insides (how it is made, of what it is made). In a good, smoothly working artifact, materials and mechanisms of operation become, in a sense, invisible-or, as Polanyi would say, tacit.
We can illustrate Polanyi's idea of tacitness by considering use of a pen. I'm writing on this pad now with a pen. As I guide the pen along the paper, I am not paying attention to the pressure of my fingertips on the pen. If you numbed my hand, I would have a difficult time writing, although I'm not aware of the pressure at all in the normal course of writing. When I first was learning to write with a pen, I probably was aware of such details.
I'm paying attention to the content of what I am writing, rather than to the process of writing. I manipulate the mark on the paper from a sensory base of which I am systematically unaware. In fact, I have to become unaware of it to become expert in using the pen. The sensory basis on which I use the pen becomes invisible if I know how to use the pen well.

JLB: Then, anything that goes wrong becomes a source of breakdown-running out of ink or having to press especially hard because of the surface.
DAS: When my pen begins to run out of ink and I have to press it, then I become aware of the interaction between me and the pen.
JLB: I suppose that this kind of invisibility occurs in other areas of design. I'm thinking of the design of buildings in a city in particular, where we want to be guided by unobtrusive, culturally accepted clues indicating what the building is, where the entrance is. We rely on various cues, indicators, conventional signs-not in the sense of a sign that says "door," but rather of some architectural feature to which a person can relate appropriately-what Brown and Duguid (Chapter 7) call the border.

DAS: That's right. In that sense, the city, or the building boundary, or the building is more like interactive software-the software that's made for interaction with human beings on a contingent basis, for a particular purpose. In good design, access to the functionality is more like the visibility of a door, and I suppose is less like the hidden

aspects of a pen-at least until the pen fails.
JLB: So far, we have discussed several aspects of the design process. Shahaf Gal (Chapter 11) describes how they showed up in studies that you and he participated in of design students at MIT. Can you say more about that experience?

DAS: Yes, we did a series of case studies of activities in Project Athena-MIT's integrated educational computing environment. Sherry Turkle and I, assisted by several of our graduate students, studied what happened as students were using experimental software that the faculty members were developing in conjunction with their teaching. It was amazing how much difference there was between the intentions that the faculty had for their software and the experiences that people had in using it.

For example, one teacher had developed two programs for students in the mechanical engineering department; they were called McCavity and Growltiger. McCavity was programmed to be an intelligent tutor. It was capable of figuring out your weaknesses in understanding statics and of teaching you what you needed to know, correcting your errors.

The other program, Growltiger, was not conceived as a teaching program at all. The author considered it to be a design tool. It incorporated a finite element algorithm for studying equilibrium forces. You drew on the screen a structure such as a beam or a truss for a bridge, you specified the materials and the dimensions, then loaded the bridge, and the program would show you deflections (see Figure 9.2). It would also show you moment diagrams and shear diagrams for that bridge.

>>>>>>INSERT FIGURE 9.2 ABOUT HERE<<<<<<

Figure 9.2 Computer Simulation of Structures Students could enter a proposed design of a structure into the Growltiger program to simulate the structure's behavior under different load conditions. Growltiger was used by students to explore the space of possible bridge designs, and to find surprises that could lead to major shifts in their understanding of their designs. (Source: Courtesy of the Massachusetts Institute of Technology.)

We interviewed students about their use of these two programs, and we also observed them working with the programs. It turned out that their dominant response to McCavity-the tutoring program-was boredom. The program was telling them what they already knew. Or, if they didn't know it already, they didn't want to learn it that way. What they did was to turn their intelligence against the program, subverting it so that-instead of tutoring them-it just gave them the answers to their homework problems.

The case of Growltiger was markedly different. Although Growltiger was not intended to be a teaching tool, it functioned as though it were. The students would draw a structure. They would load the structure. They would observe the deflection and say, "My God, how could that possibly happen?" And they would puzzle over the surprises. That is a process of reflection in action: interacting with the model, getting surprising results, trying to make sense of the results, and then inventing new strategies of action on the basis of the new interpretation. Students could iterate very quickly with this design tool.

JLB: It sounds like the program was genuinely interactive, conversational.

DAS: Conversational was exactly the word that was used. Each student was having a conversation with the materials as represented in the computer system. Puzzles came out of the surprising phenomena that the conversation produced-surprising to the students in view of their prior understandings of the way the structure would behave. They had equations available to describe the behavior they were seeing, but didn't think about those equations in relation to the physical phenomena until there was a surprise.

The visual representation was extremely important because it provided something to contrast with the symbolic representation-the formal symbols of the equations. In the conversational interaction with the program, students came to see equations in a different light from what is portrayed in a traditional statics course. A student could consider a question that emerged from experiment, such as "What on earth makes this structure become stiffer as I take material away?" and then grasp the formal theory in a new way.

JLB: So what was intended as a design tool was in fact a vehicle for learning, as the students described it?

DAS: That's right. I remember interviewing the graduate student who had helped to develop the program. The graduate student was dogmatic: The program was not for teaching. So you could say that the developers of the program did not understand what they had created. What they were designing was not what they thought they were designing. They couldn't discover that until someone was able to observe the program in use and to interview its users.

Here the issue is not only, "How do I make this artifact usable?" but also, "What is this artifact?" I don't know what it is until I enter into-get access to-the experience that users have with it. That opens up the possibility that, if I learned more about what users did with it, I might think about redesigning it to suit their needs.

JLB: You have also written about the development of taste as one attribute of a good designer.

DAS: I use the term taste when I'm talking about the discriminatory appreciation of objects, with respect to, among other things, how well they are designed. A good designer has to have taste. It's clear that having taste isn't sufficient for being a good designer. But you do need to have it, in the sense that you're able to make judgments of quality in many different ways. This discrimination needs to be roughly congruent with the more discriminating of the users for whom you are designing.

JLB: So there needs to be a connection between the taste of the designer and the taste of the people who will be users.

DAS: Unless there is, it is highly unlikely that the designer will produce an object that appeals to those users. In my relationships with doctoral students, I'm trying to help them become designers-designers of research or designers of artifacts. One thing that I watch for is whether they have their own gyroscope-in other words, whether they can tell when they've got something that's good. I look to see whether their sense of what's good meets, at some minimal level, my own sense of what's good. I look to see if there's a big gap that I interpret as a gap in quality, showing that they haven't gotten there yet.

JLB: To say, "They haven't gotten there yet" implies that they could get there, rather than, "Either you have it or you don't."

DAS: Right! It is not at all, "Either you have it or you don't." In fact, it is exciting to see that gyroscope develop over the years-and it does take years.

The reason that the gyroscope is so powerful is that, if students have it, then they can look at their own work-maybe not immediately, but, perhaps a week later-and then can say, "Oh damn, this is terrible!" If they don't have the gyroscope, they can't say that. They keep thinking that their work is good, and when you say it isn't good, they feel terribly let down and also mystified because all they can say is, "What's wrong with it? It looks good to me."

JLB: So taste can't be characterized in terms of specific attributes that you can describe?

DAS: No, it can't. As part of our exploration of taste, every year we have students bring in an object that they consider to be well designed, and then we listen to how they talk about it. We often are surprised by the way that students describe the objects. It is clear

that they love these things. One year in particular this point came out in a powerful way with a group of people-one guy brought in his bicycle, another guy brought in his sugar bowl, and another brought in a pen. The way that they talked about these things was profound and moving. Sometimes, we go back and analyze what they say, and we try to discover the attributes that are important to them. We notice that there seems to be a lot of ambiguity, not only with respect to what the relevant properties are, but also with respect to what the relevant dimensions are.

The student who brought in the sugar bowl tried to describe why he liked it-what it was about it that he really liked. He was trying to figure it out, because it wasn't obvious to him-he just knew that he really liked that sugar bowl. He talked about the size of it, that he could fit it in his hand. He held it with his two hands on the sides. He liked the sculptural form of it; the ridges on it were helpful. He liked a particular aspect, the place where you could put the spoon in and a depression that allowed you to get a tight fit and closure with the lid. It was a personal statement.

JLB: So he had a personal connection with the attributes of the object?

DAS: Or a personal connection with this particular object was justified by reference to its attributes. The object had an overall appeal for that student. And then, prompted by the situation where he was called on to describe why, he pointed to attributes. But the attributes themselves were not necessarily central-there was something about the design of the object as a whole. The overall impression was distinct from the attributes of the components. As I thought about the students' descriptions, it was clear that the presence of multiple dimensions, multiple attributes of each dimension, and unresolved ambiguity about them, held true across the board for all the objects that the students selected-and about all the objects that we design for people.

When the students are describing an object that they consider to be well designed, I argue that a personal response to the object has a relationship to taste. Taste is the familiar term. I suppose love is another term-people love certain objects.

Designers need to be able to bridge this gap between the personal and the technical-to be able to work with the medium and to reflect on the surprises, and in the end to produce a design that works both for the designer and for the audience. Not every designer can produce a design that evokes love, but that's not a bad description of what good design is trying to achieve.

Suggested Readings

Michael Polanyi. The Tacit Dimension. Garden City, NY: Doubleday, 1966.

Donald Schön. The Reflective Practitioner: How Professionals Think in Action. New York: Basic Books, 1983.

Donald Schön. Educating the Reflective Practitioner: Toward A New Design for Teaching and Learning in the Professions. San Francisco: Jossey-Bass, 1988.

About the Authors

Donald Schön is Professor Emeritus of Urban Design at MIT. He is best known for his studies of professional practice. He has also written books on other aspects of social organization and technology, including Technology and Change (1967) Beyond the Stable State (1971), Frame Reflection (1994), and, with Chris Argyris, Organizational Learning (1978).

John Bennett recently retired from IBM after a long and productive career in interaction design. He has been active in the ACM Special Interest Group on Computer-Human Interaction (SIGCHI), where he has served as conference technical program cochair and on the Advisory Board.