Chapter 5:

The Experience of a Physical Medium

5.1 The Senses

The senses are our input devices. Scientists are only beginning to put together the complex relationship between our sense organs, brain, and behavior. “The latest findings in physiology suggest that the mind doesn’t really dwell in the brain but travels the whole body on caravans of hormone and enzyme, busily making sense of the compound wonders we catalogue as touch, taste, smell, hearing, vision.” [1] Both Ackerman [2] and Csikszentmihalyi [3] state that information gained from sensory input is crucial to survival and that our senses have evolved to provide such information. For example, the sense of taste has evolved so that we can distinguish nourishing substances from harmful ones.

Ackerman [4] and Csikszentmihalyi [5] also suggest that the experience of pleasure is inextricably intertwined with informative sensory input. We respond positively to certain stimuli, actively seeking it out and thereby increasing our chances of survival. For example, food that is good for us tastes good (in the natural world—not the processed world of chocolate and potato chips!), and things that are poisonous taste bad. Also many foods have appealing colors and shapes. Try taking some toddlers (who have few preconceptions about food) for a walk in the woods and they will want to pick every berry they encounter, examine it close up, feel it, squeeze it, and eventually taste it. If it tastes good, they will want more; if it tastes bitter (poisonous), they will spit it out. The interconnection between pleasure and survival is so crucial that if we didn’t enjoy looking at other humans, or touching and being touched, we would probably never reproduce, and our species would die out.

In Chapter 3, I discussed how sensory richness plays a large role in our experience of a physical medium. It defines its appeal and supports skill and technique development for the designer. Sensory richness also supports cognitive processes such as learning and memory.

5.1.1 Constructionist Learning

The experience of interacting with a physical medium combines sensory input with cognitive and motor processes. The result is a rich experience that enables creativity, learning, and problem-solving to occur. A parallel can be drawn between designing and the education model known as constructionist learning. Much of the research into constructionist learning substantiates a multisensory, creative, problem-solving approach that embodies knowledge and thus fosters deeper learning. Take, for instance, my nine-year-old daughter's recent social studies segment on Egypt. Besides hearing lectures and demonstrations at school, she was asked to write a report, construct a diorama, and make an Egyptian costume to wear to a banquet where she ate Egyptian food.

Constructionist learning is learning by making. It puts every student in the role of designer. As Papert [6] suggested, children are builders of their own intellectual structures. Builders need building materials. It is well accepted among educators that this type of multifaceted approach makes concepts more concrete, deepening their understanding and making them more memorable. Computers are not excluded from this model of learning. They contribute to this approach by making complex dynamic systems more concrete and comprehensible. Physical artifacts contribute by addressing multiple senses, which makes many other types of knowledge more comprehensible and memorable.

5.2 Interacting with Physical Media

The experience of exploring what a physical medium can do is cognitively, physically, and emotionally engaging and further clarifies the design experience. One such concept, a *state-space,* refers to the perimeter of possibilities within which a designer can explore the physical properties of a medium (discrete or continuous, elastic or plastic, soft or resistant), together with the hands or tools used to work a medium [7].

5.2.1 Discrete Physical Media

Consider the process of composing a design with Lego blocks or a similar construction toy. The designer instantiates vocabulary elements by moving them into a work space. These instances can be grouped by snapping them together. Instances or groups can be selected and moved (translated and rotated) into new positions. The vocabulary of elements, together with these operators, establish a state-space for exploration. A simple three-dimensional computer modeling system might provide exactly the same vocabulary and operators, and thereby establish a comparable state-space for exploration [8].

For construction toys like these, any path through the state-space generates a series of sensory experiences: You feel the hardness and weight of the elements and subassemblies with your hands, you experience translations and rotations both visually and kinesthetically, you hear and feel the elements click together, and you may even smell the materials. These pleasurable and engaging qualities of the sensory experience help to motivate exploration and, as constructionist theory suggests, they support effective learning about the domain that is being explored.

This sensory experience is generated not only by the application of operators but also by the testing of states. You can pick up configurations of elements to feel if they are heavy or light, you can explore their properties of balance, and you can gain insight into structural stability by witnessing structures wobble and collapse. The results of such probes have suggestive power; if you see that a structure is about to topple over, for example, you might add elements to balance it. You might feel challenged to push configurations to their limits of stability.

By contrast, the comparable experience of exploring such a state-space with three-dimensional modeling software is sensorily and affectively barren. States are presented on the display with two-dimensional graphics, and the tactile, auditory, and olfactory dimensions are missing. The application of operators typically offers no sensory experience at all beyond selecting and dragging with a mouse within a GUI. Constructionist theory suggests that opportunities for learning in this environment will be correspondingly diminished.

5.2.2 More-Complex State-Spaces

Building blocks, such as Froebel blocks, support more-advanced exploration through some subtle but crucial changes in physical properties. They provide a limited vocabulary of discrete elements, like Lego blocks, but they do not snap together. Instead, they allow translation and rotation increments to vary continuously. Therefore, they establish a state-space that is discrete in some aspects and continuous in others. Also, the ways that you probe the states are different. Rather than picking up large subassemblies of Froebel blocks, because they would fall apart, you build up assemblies on the floor and slide them around along the floor plane. You experience a world controlled by gravity instead of attachment, that is unless you use glue [9].

Another type of state-space results if you replace chunky, rigid elements with thin, elastic ones. These may consist of wooden or elastic strips that function as splines, the springy tape preferred by automobile designers, or thin sheets of paper, metal, or plastic. The resulting state-space includes not only instantiation, grouping, translation, and rotation operators, but also elastic deformation operators. The sensory experience has enlarged to include the feeling of springiness and resistance. If you deform elements beyond their elastic limits, you introduce another complexity into the state-space. You get compositions of bent metal rods or folded cardboard.

If you utilize operations of cutting and material removal, another dimension of design variation results. If you apply tools to sheet cardboard, such as scissors or knives, a state-space results that is appropriate for architects who want to explore compositions of planes for walls, floors, and roofs. If you apply saws or chisels to solid blocks of wood or stone, you have a carver's state-space. The comparable operation is the subtraction operator of a solid modeling system. The experience of the carver's realm can vary considerably, depending upon the hardness, softness, or granularity of the material.

Modeling clay has a state-space in which shapes and initial vocabulary elements are not preserved. The units of construction are freeform blobs. These blobs are not elastic but deform plastically and retain their shape. Material may be removed from a solid mass, but it may also be added to a mass, so that shapes are constructed by accrual. The designer's experience is an intensely tactile one, with the feel and resistance of the clay on the fingertips playing a crucial role.

5.3 Summary

Physical design media establish state-spaces in the same way that digital media do, but the experience of exploring these state-spaces is generally a much richer, more multisensory one. Because of this rich sensory feedback, physical media possess cognitive, motor, and emotional advantages over disembodied digital media. Through sensory appeal, they attract and inspire exploration. Through spatial qualities, they facilitate understanding of complex geometric forms and enable easy juxtaposition, pointing, and gesturing. This richness and complexity is often highly engaging and emotionally satisfying, thereby establishing conditions for creativity and learning. These are all convincing reasons why designers have not abandoned physical media, even with the availability of the digital medium.