Tinkering by Design: Thoughtful Design Leads to Breakthroughs in Thinking

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Wooden blocks and colorful wires are spread out over a large table. Mounted on the blocks are all kinds of small electrical devices—lights, buzzers, bells, switches, dimmers, motorized toy parts. People gathered around the table are busily connecting and reconnecting the wires' alligator clips to the blocks' steel nails in various configurations as they work through their understanding of electrical circuits. From time to time a bulb lights, a buzzer buzzes, bells ring, motors whirr. Expressions of delight and wonder punctuate the low hum of conversation as circuits are successfully completed. Simple circuits—connecting a light bulb to a battery—naturally lead to more complex ones—three lights in a series or the integration of a switch. In time, some people start creating complex circuits incorporating polarity-dependent components, double-pole and double-throw switches, hand-crank generators and more.

There are no prescribed or correct ways to proceed. People explore however they choose to, sometimes experiencing breakthroughs in thinking about circuits; other times to results that don't work out but are easy to rethink and reconfigure and may ultimately bring about new understandings.

The Tinkering Studio

The circuit board table is one of the activity areas in the Exploratorium's *Tinkering Studio,* a space dedicated to exploring the world by making things, where visitors can have a seat, slow down, use their hands and share ideas with others to investigate phenomena, materials and tools. The studio, the activities and the facilitation are all carefully designed to help cultivate what we call a "tinkering disposition"—a proclivity for seeing the world as something that can be acted upon and building confidence in one's ability to do so.

A Welcoming Environment

The physical space of the *Tinkering Studio* is designed to feel welcoming. The boundary between the studio and the rest of the vast, open-space museum is clearly marked by low walls that define the space but do not cut off visibility. An attractive display near the entrance, filled with artifacts made in the studio, gives a sense of what to expect inside. A gated entrance allows staff to moderate the number of visitors to provide optimal facilitation at any given time. Offering the best possible tinkering experience to a limited number of people is preferred over maximizing throughput.

To make the space feel informal and relaxed, spatial elements (ceilings, table size and height, number of stools, etc.) are scaled so that visitors feel neither cramped nor "lost in space." Special attention is paid to lighting. Warm table lamps, the main source of illumination, create a living-room-like atmosphere; overhead lights are used for accents, highlighting artifacts on the walls and creating pockets of light and shadow that provide dimensionality.

The shape and placement of furniture encourage and support relationships: large rounded tables with materials spread over them and visitors facing each other help make cross-talk and unplanned interactions between strangers easy and natural. In this way, temporary tinkering communities emerge in which people learn by working together.

The Tinkerability Factor

The simple design of the circuit boards activity illustrates the elements essential to developing a tinkering disposition. We use real circuit components in which all parts are visible. Electric devices are mounted on ordinary wooden blocks to convey the sense that the materials are handmade and approachable, not daunting the way high-tech manufactured electronic gear might seem.

Materials are plentiful enough to allow for a variety of experience levels and simple enough so that entering into the activity is fairly easy. Even if the materials are unfamiliar, it takes only a few moments of tinkering and/or watching others around the table to figure them out. Learners begin working with whatever materials they find most accessible or interesting, which is what makes this activity particularly compelling.

There are no step-by-step instructions. Involvement relies on curiosity and experimentation. The circuit parts indicate when things are working and when they are not—the light bulb will come on or it won't. Phenomena give feedback to the learner. Small insights happen quickly. The learner can decide how to hook things up and what to try next. Mistakes occur and we choose not to design those possibilities out. It is often through making mistakes that true understanding comes about. We have noticed again and again that when visitors' circuits don't work as planned, they do not give up, but are motivated to think more deeply to solve the problem.

Like all activities in the *Tinkering Studio,* circuit boards have key elements that create the intangible quality of tinkerability. In *Design Principles for Tools to Support Creative Thinking,* Mitchel Resnick, founder of the Lifelong Kindergarten group at the MIT Media Lab, writes that a productive learning environment can be quickly established for a wide range of personalities and expertise levels through the use of tools that have a "low threshold, high ceilings and wide walls." In the *Tinkering Studio,* our shorthand definition of these elements are: *low threshold*—begin with something very simple; *high ceiling*—provide enough materials, tools and equipment to allow visitors to set ever-more demanding challenges for themselves; and *wide walls*—list no predetermined outcomes.

Non-intrusive Facilitation

Facilitation in our tinkering environment is an exercise in observation and restraint. It involves being attentive to the fluctuating levels of frustration that are part of the ebb and flow of tinkering, and when learners reach the limit of what they can achieve by themselves, providing just enough assistance to get them unstuck. This could mean silently offering a new material, encouraging someone to look at another's solution to a similar problem, or asking questions rather than providing answers.

Ever-evolving Design

The *Tinkering Studio,* an experiment in the purposeful design of a learning environment, is intended to meet everyone where they are when they arrive, to support relationships among those working in the area and to deepen and extend their thinking by the time they leave. Interactions in the studio are a starting point for lifelong investigations of the world, and we carry that same attitude when it comes to our own work. True to our educational philosophy—tinkering and learning by doing—our work in the *Tinkering Studio* will never be "done." As we continue to evolve, remix and iterate, it will always be our latest, best shot.

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