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My personal experiences with computational objects relates to the Resnick, Berg, and Eisenberg article *Beyond Black Boxes: Bringing Transparency and Aesthetics Back to Scientific Investigation*. The authors pointed out that students learning science do not often make their own instruments, so they often accept the output information without understanding how it was measured. These objects are referred to as black boxes, or opaque, because the inner workings are hidden. They also discuss that these objects are no longer beautifully made, as they once were. Their point is that learning science with these tools is an ugly mystery. I feel that this is accurate of my encounters with computational objects.

Computational objects were always "black boxes" to me. I remember using several machines in chemistry in high school and they were all opaque. We were just supposed to be used without wondering how or why they worked. This made the experiments I did more of an exercise in following directions instead of a deeper understanding of the "big ideas" of chemistry. Until I took the cover off the tower of my computer in order to dust it out, it held the same mystery. Seeing the inner workings and how parts fit together piqued my interest, and I decided to learn more. However, no matter how much I learn about computer hardware and software, computers still seem intangible.

In the article, *Mindstuff: Educational Technology Beyond the Computer*, Eisenberg examines some of the key points in Seymour Papert's book, Mindstorms. Eisenberg feels that computers are limited, that they are not "…things that could be handled, touched, smelled, placed on a shelf or in one's pocket, collected, traded, and decorated." Papert described how he loved gears in the introduction to his book, and he hoped that computers would become tangible objects that children would come to love as he had. Instead, computers have become the black boxes the Resnick, Berg, and Eisenberg described.

Resnick points out in his article, *Technologies for Lifelong Kindergarten* that current research has argued "…that people form their strongest relationships, with knowledge through 'concrete' representations and activities." The concepts I feel I really understand were always learned through experiences with concrete objects. For instance, my understanding of multiplying and dividing fractions came when I was doing my student teaching and the teacher used plastic circles divided in to sections to show what was meant by the computations I had always performed without thinking. I know that at some point I had to have asked myself, or the teacher, "Why do you flip and multiply? How does that work?" I do not think I was ever provided an answer, and was certainly never given a representation with physical objects.

Trubak and Berg describe a class at Wellesley College in their article, *Robotic Design Studio: Exploring the Big Ideas of Engineering In a Liberal Arts Environment*. In the course, college students use programmable bricks and arts and crafts materials to design computational objects. The description of the end product is vague and students can use a massive variety of materials. What the course is trying to accomplish is to get across the "big ideas" in engineering, not to make the students engineers or computer programmers. "The essence of engineering is imagining something…designing it, building it, and getting it to work…students learn that engineering is an iterative process in which they continually implement, test, debug, and refine designs." (Trubank and Berg, p.14) This is the type of experience that would have been valuable for me. Having the opportunity to understand that I can use the hardware to design a product that has some usefulness and meaning to my personal experiences, something original and concrete would have been very meaningful.