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Middle-School Science Through Design-Based Learning versus Scripted Inquiry: Better Overall Science Concept Learning and Equity Gap Reduction

We were motivated to understand how thinking happens in the engineering design process. There is something about design thinking that gets people engaged in problem solving, whether they are engineers or not. This way of thinking begins with having people work from their own needs and then projects to their own desired outcomes. We wanted to see if we could understand the ways in which design thinking happens and harness that structure of thinking so that it might be possible to increase student motivation and engagement. As it is, one of the biggest impediments to getting people interested in becoming engineers begins in science and math classes at a young age when students never get a convincing answer to the question "Why do I need to learn this?" We hoped that by using design connected to individual needs, this question never really comes up in the first place and therefore never becomes a barrier to learning.

We built the study in a context of a lot of existing research on design in engineering. The work of Herb Simon as discussed in "The Sciences of the Artificial" provided perhaps the broadest base for understanding modes of thinking in design. The work of Kolodner, Harel, Papert, Kafai, and Klahr, Dunbar, and many others have explored design reasoning and constructivist learning from many different perspectives. What we wanted to do was to contrast how modes of thinking in a design process stacked up against modes induced in a traditional science curriculum, head-to-head, specifically so that students needed to construct their own experiments with little scaffolding. Design would provide the motivation and "need" for a set of experiments in order to "get something to work." The performance indicator was whether or not students learned *science content* better in this design cycle.

The study contrasted performance overall and by gender, ethnicity, and socioeconomic status (SES) for middle school students learning science through traditional scripted inquiry versus a design-based, systems approach. Students designed and built electrical alarm systems to learn electricity concepts over a four week period using design methods. The contrast study took place in the eighth grade of an urban, public school district, with the systems approach implemented in 26 science classes (10 teachers and 587 students) and the scripted inquiry approach implemented in inquiry groups of 20 science classes (five teachers and 466 students).

The findings showed that the design approach did produce double the learning gains when

compared to a scripted inquiry approach. The design approach helped low-achieving African American students, in effect eliminating achievement gaps.

These results were significant, as they formed the basis for a summer program Research Experience for Teachers, for which teachers learned about engineering design and then created their own design-based curricula, from which their students created designs for a regional design competition. This program has led to an increased interest and motivation for young people to become engineers and scientists.

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