

## Research questions

Are grade school students capable of performing design tasks related to nanoscale self-assembly? How does the contextualization of these tasks within domain language affect student understanding? This pilot study examined these questions by looking at the effect on students' conceptual understanding and ability to perform design tasks as a function of the sequencing of the introduction of domain specific terminology. In traditional science instruction, students are presented with a new topic and related terminology through a lecture by the teacher, which is often followed by some hands-on activity to further foster conceptual understanding and interest. However, research suggests that this traditional sequence of instruction may hinder student learning by evoking misconceptions and prior negative experiences with scientific language (Barnes, 1990; Dykstra, Boyle & Monarch, 1992), or by cognitively interfering with conceptual understandings (Schwartz and Martin, 2004). A sequence of instruction in which the design task is introduced using morphological descriptors and is subsequently bridged to the domain terminology only after the design experience may mitigate those issues. In addition, by providing appropriate prior knowledge and a frame of reference to learn new information, students may acquire a deeper understanding of domain concepts (Schwartz and Bransford, 1998).

Barnes, D. (1990). Language in the Secondary Classroom. In D. Barnes, J. Britton, & M. Torbe, *Language, the learner and the school* (4th ed.) (pp. 87-87). Portsmouth, NH: Boynton/Cook.

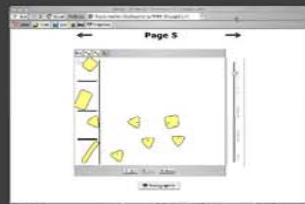
Dykstra, D., Jr., Boyle, C., & Monarch, I. (1992). Studying conceptual change in learning physics. *Science Education*, 76, 615-652.

Schwartz, D., & Bransford, J. (1998). A time for telling. *Cognition and Instruction*, 16, 475-522.

Schwartz, D., & Martin, T. (2004). Inventing to prepare for future learning: The hidden efficiency of encouraging original student production in statistics instruction. *Cognition and Instruction*, 22, 129-184.

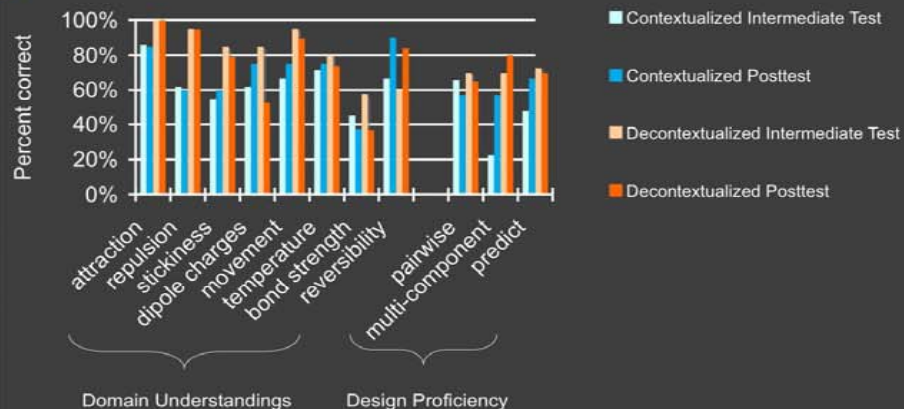
## Method

The pilot study was conducted at a Chicago Public School (K-8) whose student body is comprised of 65% Hispanic, 30% African-American and 5% Caucasian students. 93% of students come from low-income families while 8% of the population is considered Limited English Proficient. Two sixth-grade classes with a combined total of 41 students served as subjects. Researchers spent four one-hour sessions with each class over five days. One class received a *contextualized* treatment, in which one session of traditional instruction on nanoscale self-assembly was followed by three sessions performing design tasks with the Concord Consortium's Molecular Workbench. Tasks entailed choosing the type, placement, and strength of charges on differently shaped molecules in order to yield self-assembled aggregates in a desired arrangement.



The second class received a *decontextualized* treatment, in which they first completed the activity without being exposed to domain terminology. Phenomena were instead described with morphological nouns (e.g., "blob" instead of "molecule") and familiar verbs (e.g., "pull" instead of "attraction"). After three sessions of completing design tasks, a traditional lecture was presented that bridged the concepts and terms. Assessments of content domain knowledge and self-assembly design proficiency were administered to each group between the two learning experiences and again at the study's completion.

## Learner outcomes



## Discussion

Urban sixth grade students demonstrated substantial ability to develop conceptual domain understandings and design proficiency under both treatment conditions. While performance differences were not sufficient to assert significance on most measures, subjects in the decontextualized condition generally outperformed those in the contextualized treatment. This result runs counter to the common expectation that students require grounding in the domain prior to design activity, and provides tentative support for the conjecture that over-attention to conceptual domain vocabulary at the outset of instruction might actually inhibit learning. A comparison of the performance of students in an "instruction only" treatment (contextualized intermediate test) with those receiving both instruction and using the simulation (in either order) suggests the importance of the simulation activity as a contributor to learning.

Not surprisingly, affective responses (not reported here) showed a preference for activity over didactic instruction. This was also reflected in the intermediate-to-post-test differences on learning measures, with students in the contextualized condition generally benefiting from the activity following instruction, and students in the decontextualized condition generally showing little improvement.

In Fall, 2007, we will conduct a follow-up study introducing a third, *recontextualized*, treatment condition, in which domain-specific and neutral vocabulary are replaced by an intentional mapping to an alternative content domain, to see if further distancing from the content domain and recasting the phenomena (e.g., molecules as "space creatures") might have motivational and learning effects.