To create a simple audio podcast, connect an inexpensive microphone to a computer and record your voice using, for example, the Microsoft Windows Sound Recorder utility. More advanced free utilities, such as *Audacity* (n.d.) and *GarageBand* (2008), will allow you to do additional things that include the addition of sound effects and music.

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Hands-On Science: Does it Matter What Students' Hands are on?

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Abstract

Hands-on science typically uses physical materials to give students first-hand experience in scientific methodologies, but the recent availability of virtual laboratories raises an important question about whether what students' hands are on matters to their learning. The overall findings of two articles that employed simple comparisons of physical and virtual materials suggest that virtual materials could be an effective and efficient alternative to physical materials when teaching with explicit instruction and discovery learning methods. (This paper is a summary of Klahr, Triona, & Williams, 2007 and Triona & Klahr, 2003)

How should we teach science? Traditionally, the primary method to teach science was having students read textbooks and listen to lectures in which major scientific findings were described as facts and the particulars of scientific methods and procedures were often minimized or omitted entirely. In contrast, hands-on science teaching brings the scientific methods used to produce new scientific knowledge to the forefront. In hands-on science, students' concrete, kinesthetic actions are related to abstract concepts and these activities tend to increase student motivation and engagement (Flick, 1993; Haury & Rillero, 1994).

Two recent developments in science education motivated the current research. In California, policymakers ignited controversy when they specified how much hands-on science should be in the curriculum (Woolf, 2005). Starting as a 25% maximum, the policy was eventually switched to a 25% minimum. The other development is the increasing access and quality of computer-based, "virtual" materials for science education (e.g., Davis, 2007; Dillon, 2006). These convergent developments raised an important question: Does it matter whether the hands-on activities are executed with physical or virtual materials?

When comparing physical and virtual materials, there are at least three potentially important dimensions to consider: (1) What is being taught? Is it a process skill, such as creating controlled experiments or filling out tables of data, or is it particular facts and concepts, such as the speed of light or the structure of the carbon atom? (2) How is it being taught? Where on the broad spectrum from explicit instruction to discovery learning is it? (3) Is it hands-on or hands-off instruction?

Because there are so many different aspects of hands-on science instruction (Flick, 1993; Hmelo, Holton & Kolodner, 2000), simple comparisons were needed to compare the effectiveness of physical and virtual materials. Here we summarize two papers (Klahr, Triona, & Williams, 2007; Triona & Klahr, 2003) that begin to answer how the type of hands-on science influences different kinds of learning."

Learning to Design Good Experiments With Explicit Instruction

Many studies have found that elementary students often design flawed experiments in which they change multiple things at once, thereby making it impossible to determine which change caused the effect (e.g., Kuhn, Garcia-Mila, Zohar, & Andersen, 1995; Schauble, 1996). However, directly teaching elementary children how to control extraneous variables can be very effective and students can then transfer this skill to other experimental situations (Chen & Klahr, 1999).

By developing a virtual version of those physical materials, we could compare students' learning with physical materials to their learning with virtual versions of the same materials. The virtual materials mimicked the physical materials as closely as possible (see Figure 1) to ensure that, if there was a difference, it was the version of material making the difference.

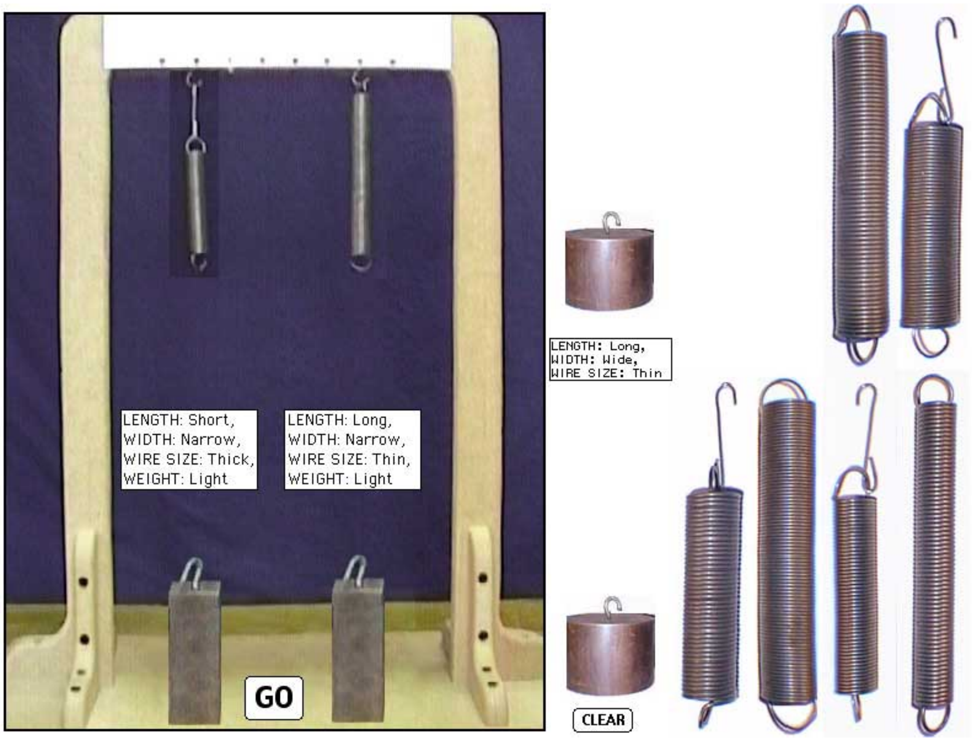


Figure 1. Shown here is the computer interface that children assigned to the virtual materials condition used to design comparisons of different types of springs during the pretest and posttest and that was used for their instruction on creating comparisons that controlled extraneous variables.

In our first study comparing physical and virtual materials (Triona & Klahr, 2003), we randomly assigned 92 fourth- and fifth-grade children to use either physical or virtual materials to design comparisons of different kinds of springs both before and after receiving explicit instruction about how to design good comparisons. A week later, in order to determine whether students could successfully transfer their new skill to another context, all children used physical ramps to design additional experimental comparisons.

We found that, on a variety of measures of learning, there was no difference in the performance of children trained with physical materials and virtual materials; both groups showed similar gains in their learning to design good experiments (from 20% pretest to 60% posttest and transfer). Children in the virtual materials training group could have been at a disadvantage during the transfer phase because they changed material type (from virtual to physical) and domain, while the physical materials training group changed only domain. However, there was no significant difference between groups. Moreover, type of material did not influence children's learning from their comparisons about the effects of the variables, nor in whether they verbally explained the importance of controlling variables. These findings suggest that instruction using either physical or virtual materials is equally effective at teaching elementary school students' how to design unconfounded experiments, at least when using explicit instruction.

Learning the Effects of Variables with Discovery Learning

But perhaps the impact of physical versus virtual materials would be different in a discovery learning context? Our second study (Klahr, Triona, & Williams, 2007) addressed this issue. We compared physical and virtual materials in a context in which middle school students attempted to learn about a novel domain while using a discovery method. In this study, 56 seventh- and eighth-grade students built and tested several "mousetrap cars" (see Figures 2 & 3). These cars have several factors that influence the distance that a car will travel once it is released. Students were given the engineering task of designing a car that would travel the farthest--they were not asked to design unconfounded experiments. Half of the students built and tested their cars virtually while the other half used physical materials. To examine the influence of the virtual materials taking less time to build and test, the groups were further divided with some having 20 minutes to build and test cars while the others were asked to build and test six cars, regardless of the time it took.

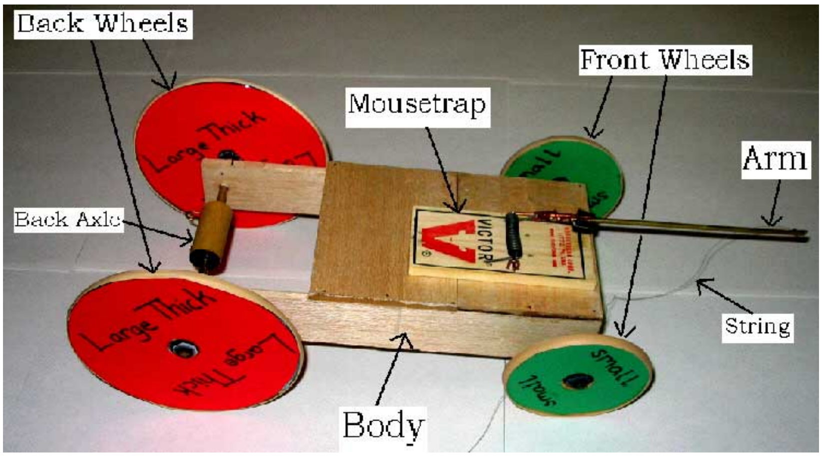
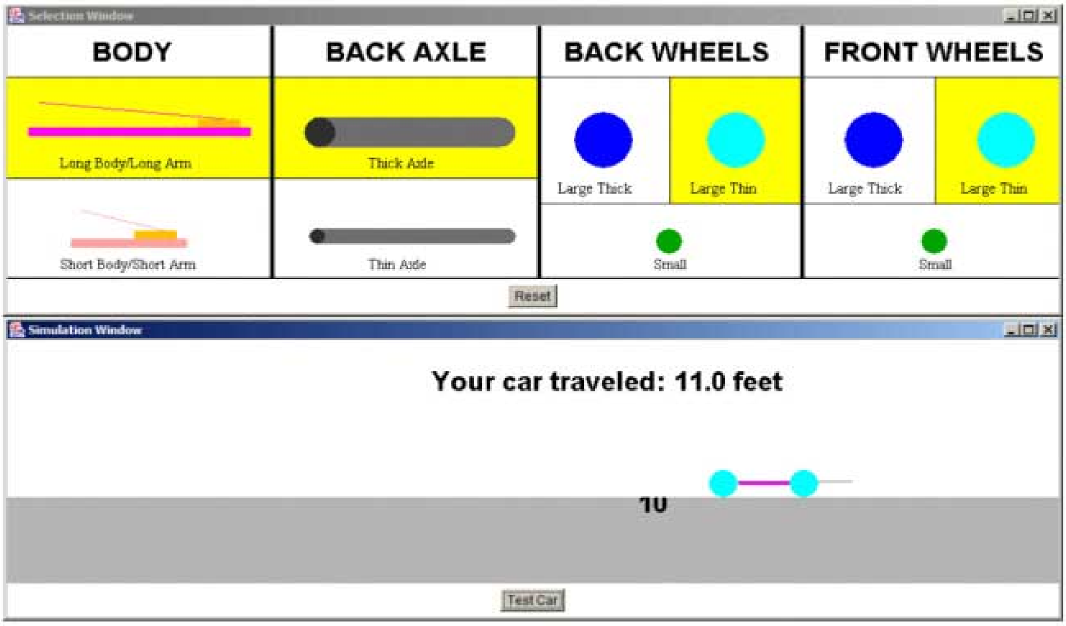


Figure 2. Mousetrap car built using the materials that children assigned to the physical materials condition used.



Your car traveled: 11.0 feet

Figure 3. Computer interface used to build and test mousetrap cars by children assigned to the virtual materials condition.

How did students' ideas about the effect of each car feature (i.e., size of wheels, wheel thickness, length of body, axle thickness) change after designing and testing their cars? Students from all groups improved in their accuracy of car feature effects regardless of whether they were using physical or virtual materials, built 6 cars, or worked for 20 minutes. In particular, student learning for all groups was most pronounced for the four causal variables (from 51% correct to 91% correct). However, there was no significant change for the non-causal variables in any of the groups, which concurs with prior research that finds identification of non-causal variables is especially difficult (Kuhn, Schauble, & Garcia-Mila, 1992).

As expected, students were faster at building and testing the virtual cars than the physical cars, but despite the reduced time spent by children who only built six virtual cars, they learned a similar amount. Equally interesting was the result that students who built virtual cars for 20 minutes--testing many more cars than the other students--did not learn more than students who built and tested fewer cars.

In summary, children showed similar improvements in their understanding of the causal features of mousetrap cars regardless of whether they used virtual or physical materials. These findings suggest that "hands-on" science using virtual materials, which can also be more efficient (i.e., take less time and resources to develop and use), could be an effective alternative to the use of physical materials.

Conclusion

The incorporation of technological tools already plays an important role in science classrooms (Davis, 2007) and the current studies suggest that virtual materials could be a viable option. However, there might be particular domains (e.g., life sciences) that require experience with authentic, physical objects rather than their virtual equivalents (Apkan, 2002; Eberbach & Crowley, 2005). Much still needs to be learned about the influences of different instructional materials on student learning.

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Ideas in Brief

Ideas from key articles in reviewed publications

Blogs

Journal writing (e.g., learning logs, learning journals, think journals, and reflective journals) have been widely used by educators, although less so by science teachers. A blog (an abridgment of the term web log) provides an on-line journaling experience that Johnstone (2007) suggests can play a useful role in science education, including being used to record students' progress with extended experimental investigations.

Blogger (2008) and *Edublogs* (2008) are two free, user-friendly blogging services that a student can use to set up a blog in only 5 minutes. A blog can play the role of a laboratory, or log, book for keeping a record of experimental work, and can even adopt the style of a formal experimental report. A blog can also be commented on by the teacher, other students, or anyone else with the password.