

## **Deeply Digital Student Engagement and STEM Learning with Models and Probes**

### **Background**

The Concord Consortium is a nonprofit R&D organization in Concord, Mass., dedicated to transforming education through technology. Our free, deeply-digital tools and learning activities capture the power of curiosity and create revolutionary new approaches to science, math, and engineering education that bring out the inner scientist in everyone. Since 1994, we have been pioneers in probeware, models and simulations, data collection with mobile computing, online assessment and teacher professional development, and the nation's first online high school.

The Molecular Workbench is a software suite providing visual, interactive computational experiments for teaching and learning science, including a full set of simulation engines enabling students to explore the atomic and molecular world firsthand, a wide ranging suite of curricula from biology to chemistry to physics, and in-depth assessment capabilities that provide an in-depth view of student understanding.

Our High Adventure Science activities engage students with unanswered questions in Earth and space science today, exploring cross-cutting ideas such as feedback loops and complex systems in the process.

Our Evolution Readiness series of activities helps elementary school students learn about the underpinnings of natural selection using a curriculum involving models, simulations, and hands-on, in-classroom activities.

Our Engineering Energy Efficiency curriculum makes use of digital tools and real-time data collection via probes and sensors to teach students concepts of energy and energy transfer and help them apply these concepts in an engineering curriculum as they design, build, and test model solar houses.

The Geniverse project weaves the central concepts of genetics together with a rich narrative thread and a game-like framework to help introductory high school biology students understand the central dogma of biology and appreciate the practices and concepts that underlie modern bioinformatics and DNA science. Students experiment with fanciful dragons, designing and performing experiments, solving carefully designed challenges, and employing important scientific practices such as scientific argumentation.

In our SmartGraphs mathematics and physical science curricula, students use deeply digital tools to build essential skills and understanding about critical concepts such as graphing and graph interpretation. SmartGraphs technology provides instructional scaffolds to help students explore difficult to learn concepts.

Technology Enhanced Elementary and Middle School Science (TEEMSS) 2 is a physical science curriculum for grades 3–8 that utilizes computers, sensors, and interactive models to support investigations of real-world phenomena.

## **Documented Results**

The above projects and many more from the Concord Consortium are designed with research-based concepts at their core and with the support of measurable student learning gains as the primary goal. For many of the above projects, research studies are still ongoing. Some completed or in-process research results are below.

### *Selected examples*

- The TEEMSS 2 curriculum was found to have potentially positive effects on general science achievement for elementary school students in grades 3–4, and is listed as an effective curriculum in the prestigious What Works Clearinghouse.
- In a Rhode Island study, teachers completing a professional development program and students using a series of Molecular Workbench activities embedded in courses showed statistically significant improvements in content knowledge on a Molecular Concept Inventory (MCI). Though students had broad exposure to many topics within the courses overall, student gains on the MCI were related to the number and content of the Molecular Workbench activities they completed.
- Students completing High Adventure Science curriculum units significantly improved their scientific reasoning and their scientific argumentation ability, by 0.64 standard deviation (SD) for the “Modeling Earth’s climate” investigation, 0.77 SD for the “Will there be enough fresh water?” investigation, and 0.85 SD for the “Is there life in space?” investigation. The improvement occurred in all four elements of scientific reasoning and argumentation—claim, explanation, uncertainty rating, and uncertainty rationale—and students retained or even further improved their scientific argumentation after High Adventure Science investigations were finished.
- For the Evolution Readiness curriculum, a comparison of item maps revealed that two implementation cohorts of fourth-grade students had a more complex understanding of selected concepts in natural selection than students in the pre-implementation cohort, performing statistically significantly higher (effect sizes of 0.46 and 0.33 SD) on an assessment of these concepts.
- Students using a series of SmartGraphs activities related to the motion of objects, a standard topic taught in eighth/ninth-grade physical science classes, demonstrated greater gains on a test focused on seven motion-related learning goals than students in a control group studying the same topics using the same textbooks, and the difference was statistically significant at the  $p < 0.05$  level.

## **Potential Applications**

Concord Consortium activities are designed for use in a wide variety of classrooms and many are, by their nature, adaptable to a broad set of delivery mechanisms and conditions. They are often optimized for 1:1 computing scenarios, but teachers frequently find they can be presented effectively in groups or in whole-class instruction. Many can also be adapted well to informal settings, especially those involving hands-on, inquiry-based exploration or data collection and analysis.

Many activities provide Universal Design for Learning scaffolds and/or dual language capabilities. Additionally, many can also be customized by the teacher to suit particular topics, classrooms, or curricular demands. This capability permits their use with a diverse set of classroom applications and student populations.

## **For More Information**

All of our curricula and activities can be used free of charge. Activities, information about our research focus areas, additional projects, and lists of our published research results can be accessed at our website, <http://concord.org>. This website also provides an opportunity to subscribe to free newsletters and mailings describing our ongoing work, as well as opportunities for teacher participation in current and upcoming research and testing of educational technology for science, math, and engineering.