High-Adventure Science Final Report Summary

The goal of the High-Adventure Science exploratory DRK-12 project was to bring the excitement of frontier science into the classroom by allowing students to explore pressing unanswered questions in Earth and space science that scientists around the world are currently investigating. Students investigate the mechanisms of climate change, learn how scientists use modern tools to find planets around distant stars, and evaluate whether underground stores of fresh water will be sufficient to support growing populations.

Each of the three High-Adventure Science (HAS) investigations was designed for five class periods and includes interactive computational models, real-world data, and a video of a scientist discussing his or her computer-based research on the same unanswered questions. While it is not expected that the students will solve the problems posed in the curriculum, our goal was to have students experience doing science the way scientists do. Our goal was to focus on the *approach* to science learning—one based on students thinking critically about evidence, making predictions, formulating explanations, drawing conclusions, and qualifying the level of certainty with their conclusions. The curriculum, therefore, helped students learn to make and defend claims, plus express their levels and sources of certainty with the claims.

The "Modeling Earth's climate" investigation focuses on the question *What will Earth's climate be in the future?* In this investigation, students explore past climate changes and learn how mechanisms for positive and negative feedback can affect global temperature. They think about how scientists use this information to make climate change predictions. Students learn about where there is certainty in the climate data and where there is uncertainty with regard to predicting what will happen. This investigation pays special attention to helping students think about the presented evidence and how to evaluate the conclusions scientists can draw from the evidence.

The "Is there life in space?" investigation focuses on the question *What is the probability of finding life outside of Earth?* In this investigation students explore planet-hunting methods using a dynamic model that simulates a single planet orbiting a star. The uncertainty questions focus on data interpretation and being able to detect faint to moderate signals in noisy data.

The "Will there be enough fresh water?" investigation focuses on the question *Will there be enough freshwater resources for Earth's growing population?* In this investigation students explore Earth's freshwater resources: where they can be found, how we use them, and why we must think about sustainable use as Earth's population increases. The investigation ultimately explores why human and ecological needs should be balanced and how freshwater resource issues vary around the world.

Research

The High-Adventure Science research was based on the following research questions:

- How do students' scientific argumentation performances change after each HAS

investigation? How consistent are student performance changes across teachers? How are students' performance changes correlated with their gender, technological experience, and ELL (English Language Learner) status?
- To what extent do students who learned with HAS investigations make progress on scientific argumentation between the beginning and the end of a school year across teachers?
- How do students' scientific argumentation skills progress throughout the year?

The scientific argumentation construct used to guide the High-Adventure Science research addresses content understanding through claim and justification, uncertainty of the claim given evidence, and reasons for uncertainty as conditions of rebuttal. This scientific argumentation construct portrays authentic scientific argumentation as performed by scientists. For each investigation, HAS linked item-sets (four questions) consisting of making scientific claims (claim), explaining scientific claims based on evidence (evidence), expressing the level of certainty about explanations for the claims (uncertainty rating), and describing their source of uncertainty (uncertainty rationale).

To compare whether and how much students changed in their scientific argumentation after a HAS investigation, we created a total test score as well as subscores for claim, explanation, uncertainty rating, and uncertainty rationale items. We then applied repeated measures ANCOVA. The dependent variable was the total scientific argumentation test score and the independent variable was the teacher. Students' gender (male vs. female), technology experience (used technology for learning vs. not used), and ELL status (English as first language vs. second) were entered as covariates. We also obtained an investigation completion ratio for each teacher as an indicator for fidelity of implementation. We computed a correlation between the investigation completion ratio variable and the effect size variable. We also compared investigation completion ratios among teachers across investigations.

To compare students' yearly progress on scientific argumentation across teachers, we applied repeated measures ANCOVA where the dependent variable was the total test score on the early year and the end year scientific argumentation tests and the independent variable was the teacher. Students' gender, technology experience, and ELL status were entered as covariates.

Below summarizes the findings.

Finding 1: Students significantly improved their scientific argumentation ability after all three HAS investigations. The improvement occurred in all four elements of scientific argumentation (claim, explanation, uncertainty rating, and uncertainty rationale).

When combining all elements, students' improvement was 0.64 SD for the climate investigation, 0.77 SD for the water investigation, and 0.85 SD for the space investigation. Among the four scientific argumentation elements, students' uncertainty rating and explanations showed the most improvement while the certainty rationale showed the smallest change. These results indicate that the HAS curriculum investigations supported students' content acquisition as shown in the improvement in scientific claims, scientific reasoning as shown in the improvement in explanations, and consideration of limitations of given evidence as shown in the improvement in uncertainty ratings and uncertainty rationale.

Finding 2. The amount of student improvement after the HAS investigations differed across teachers.

There was a significant teacher effect on student improvement, indicating that scientific argumentation abilities were different from teacher to teacher. This was expected, as students were not randomly drawn from the student population. After controlling for variations due to teacher and students' gender, ELL status, and technology experience, there was a significant interaction effect between time and teacher. This can be better illustrated by comparing Cohen's d values (effect sizes) across teachers for each HAS investigation. For the climate investigation, the effect sizes varied from -0.14 SD to 1.72 SD. For the water investigation, the effect sizes varied from 0.44 SD to 3.07 SD. For the space investigation, the effect sizes varied from -0.09 SD to 2.15 SD.

Finding 3: Students significantly improved their scientific argumentation abilities over the year.

Early in the 2011-2012 school year (September and October), 11 teachers administered a pre-test. Toward the end of the 2011-2012 school year (May and June) 9 teachers administered the same post-test. Analysis was completed on 379 students who responded to both tests. Students of all nine teachers who gave both the pre- and post-tests gained statistically significantly from the pre-test to the post-test with an average effect size of 1.01 SD, a large impact.

Finding 4: Students' scientific argumentation trajectories indicated improvement over time.

On average, students significantly improved over time, $F(3,636) = 76.33$, $p<.001$. The largest improvement coincided with the implementation of HAS investigations. Students retained or even further improved their scientific argumentation after HAS investigations were completed.