Environmental Detectives: An Environmental Science Curriculum for Middle Schools
Year 3 Evaluation

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Executive Summary

Environmental Detectives (ED) is a new environmental science curriculum for middle schools, being developed by the Montshire Museum of Science in Norwich, Vermont. With funding from the National Institute of Environmental Health Sciences (NIEHS), the five-year project began in Spring 2000. During Year 2, a first round of field testing of the ED curriculum materials with two science teachers was carried out during the 2001-02 school year, with an independent evaluation assessing this initial pilot work (Char, 2003).

During Year 3, four middle school science teachers from four different Vermont and New Hampshire schools were involved in the field-testing of the revised ED curriculum unit. All four teachers were new participants to the *Environmental Detective* project. Teachers were free to choose when, and in what way, they wished to incorporate the ED curriculum into their regular year-long curriculum during the 2002-03 school year.

Independent evaluator, Dr. Cynthia Char of Char Associates, continued to follow project activities in Year 3. The main foci of this year's evaluation work with classrooms was to learn how teachers chose to incorporate the ED curriculum into their different science curriculum and classroom practices, and to assess the kind of student engagement and learning that is afforded by the ED curriculum. Research activities included observations of the summer teacher institute, student camp and regular teacher meetings with project staff, and interviews with, and observations of, field test teachers during their implementation of the ED curriculum during the 2002-03 school year. A pre-program and post-program student survey featuring a variety of student learning tasks was also administered to students in the four participating field test schools.

Classroom Implementation Results

• All teachers chose to use the ED curriculum with multiple class sections of their students, and found them to be appropriate to the interests and needs of their seventh and/or eighth grade students.

• The ED curriculum proved flexible in being incorporated into different points of teachers' year-long curriculum. Two teachers utilized ED in fairly intensive and comprehensive fashion, constituting roughly 7-9 weeks of curriculum, either in the fall or winter. Two teachers folded the ED student investigations and related activities into a broader flow of regular classroom activities, either in the fall or spring.

• Of the six activity components in the ED curriculum, the two main activity components used by all four teachers were the student-designed investigations (the ED centerpiece activity), and the activities dealing with concentrations of solutions. Three of the four

teachers elected to have scientists come visit their classrooms. Only two of the four used the groundwater activities, the case study materials, and the teacher-led experimental design demonstration.

• The primary educational value of the ED curriculum was largely defined by teachers in terms of offering students important hands-on experiences with formulating research questions, and designing and conducting scientific experiments of their own design. Teachers viewed ED as providing students with engaging, new opportunities for sustained, hands-on experimental investigations. The focus on dose response was seen as valuable not only in terms of chemical concepts and effects in the environment, but as also offering opportunities for students to be involved in engaging activities dealing with concentrations and dilutions of solutions, gathering data, and mathematical concepts and representations of percentages, decimals and graphing.

• Teachers greatly appreciated the contact with Dartmouth faculty, feeling like it expanded their own, and their students' understanding of scientific experimentation. They regarded contact with the Dartmouth scientist researchers and exposure to ED curriculum as primarily valuable in enhancing their understanding of scientific questions, hypotheses, and design of experiments, rather than necessarily in terms of the links between scientific research and real world issues in the environment, or the connection between chemistry and life sciences.

• Teachers expressed the importance of students having the opportunity to share the results of their scientific research, in the form of presentations, posters, and reports. Several schools had classroom or evening sessions in which students presented their research to classmates or parents. They also welcomed the opportunity to connect students with peers in other participating field test schools, resulting in the organizing of a spring student symposium held at the Montshire.

Student Engagement with Environmental Detectives

• Students indicated the ED centerpiece activity – the student investigations – was the most popular activity component, chosen by over half of students as one of the two activities they liked the most. The reasons that students gave for liking this activity pertained to the active, hands-on nature of the activity, and enjoyment of working with their organisms. Students also said that they liked the fact they were able to design their own activity, receive interesting results, and produce posters and reports they felt proud of.

• The Groundwater unit was the next more favored component, with students enjoying the hands-on nature and problem-solving quality of the activity. In contrast, the case study materials were much less popular, with students preferring more active learning over reading materials.

• The Dartmouth scientist visits offered an interesting, new experience for many students. A little less than half (41%) of students had never previously experienced a live presentation by a research scientist, while 29% had heard such a presentation only once. Two out of three students (63%) expressed that they found the scientist visits

"interesting" or "very interesting." Students offered a wide variety of reasons they enjoyed the scientist visits, including liking the connections between what they were doing in their own experiments and what real scientists do, being impressed by the scientists' breadth of knowledge and how much they enjoyed their work, and learning about the informational content of the presentations and chemicals in the environment.

• Less evident in students' enjoyment of ED activities was the connection between the activity and its relevance and applicability in the real world. The ED activities appeared to have been primarily received as fairly discrete "lab-based" experimental experiences.

Student Learning Afforded by Environmental Detectives

• Students began the ED curriculum with some basic level of awareness of chemicals and the environment, and did not believe that chemicals were necessarily bad for living things and the environment. Following their use of ED, students increasingly called upon their knowledge of dose response as a reason to understand the relative nature of chemicals being considered harmful or not, as evidenced by students' response to a "point-of-view debate" task (12% of students on pre-test vs. 37% of students on post-test).

• A predominant type of reasoning that held fairly steady across the field test was the view that there are both good chemicals and there are bad chemicals (e.g., oxygen and iron are good chemicals, whereas mercury and arsenic are bad chemicals.) "Good" was defined in a variety of ways, including being beneficial to, and needed by, the human body, or being put to good, practical use for people's benefits (e.g., using gold for coins, or mercury for thermometers).

• When asked to respond to a fairly challenging problem scenario and to outline an investigation of their own design, about half (51%) of the students maintained a sharp focus on one variable, while others attempted to address two or three other possible variables in their investigation. The investigations that students designed ranged from simply "educated guesses" based on details of the problem (21% of students); to initial attempts at a test of some kind (e.g., testing the water; replicating the same circumstances and seeing what happens) (38% of students), to a more formal experiment with two or more conditions (37% of students).

• Of the more formal experiments that students designed for the problem scenario task, students varied in whether they conceptualized the experiment as having primarily two values ("with" or "without" a certain variable, such as sunlight or disinfectant) (19% of students) versus experiments that had three or more values or concentrations of a certain variable (18% of students). Only 11% of students proposed investigations that had three or more values or concentrations of a certain variable, resembling a dose response experiment.

• Roughly a fifth of the students were able to outline experiments that included a variety of specific detailed experimental features, such as the number of organisms they would test, the use of replicates and controls, and what would constitute measurable results.

• When asked on a survey task to think about any concerns or questions they had about the harmful effects of things in the environment on people or other living things, students displayed no increase in the mentioning of dose, specific chemicals, or local environmental issues.

• In a group discussion at the Spring Symposium of what students felt they had learned through *Environmental Detectives*, students primarily discussed issues of experimental design, procedures and techniques. Some students also mentioned learning about dose response, and some general things about the environment.

Design Recommendations

The Year 3 field test of Environmental Detectives found that middle school teachers and students found the curriculum materials to be engaging and worthwhile, and offering interesting new opportunities for students to be engaged in sustained, experimental investigations concerning chemicals in the environment and dose response. Classroom observations, teacher interviews and student surveys also indicated several areas of the materials' curriculum design that could be enhanced and improved, as outlined below.

• Continue the ED focus on experimental design and dose response investigations. Build from students' initial notions of "good" versus "bad" chemicals and non-experimental approaches to assessing situations. Introduce them to the advantages of experimental designs that adopt more than two values of a given variable, while still maintaining controlled variables.

• Strengthen the connections between ED activities and the broader context of chemical impact in the environment. This could be achieved through more extensive use of appropriate case study materials and discussion points, and teachers encouraging greater emphasis in student reports and presentations on the connections between students' experimental designs and results, and their understanding of environmental issues and situations in the real world.

• Further clarify and convey concepts and terms relating to investigable questions, hypothesis, controls, replicates, and measurable outcomes. This could be done through teacher-led presentations, classroom discussions, original student investigations, and critiquing of hypothetical and real student investigation designs.

• Continue offering opportunities for students and teachers to meet with research scientists, and other professionals dealing with chemicals in the environment. Utilize such opportunities to enhance student's understanding of applied research related to real world issues, problems and situations, the challenges and rewards of doing scientific research, the process of formulating research questions and studies, and the type of reasoning and interpretation that's involved in making sense of research data and findings.

• Continue to provide structured student handouts outlining aspects of defining investigable questions, designing experiments, collecting data, analyzing and interpreting data, and presenting and discussing results.

• Offer improved case study materials that are interesting and easily readable by middle school students, and other information sources (both print and on-line) that connect and inform research investigations with real world situations.

• Include more structured student materials and assignments that foster students' more in-depth processing and understanding of case study materials and experimental activities.

• Provide student assessment materials, including rubrics for scoring student investigations, reports, and presentations, that both students and teachers can use to guide and assess student work.

• Encourage opportunities for students to share and present their research to classmates, parents, community members, and research professionals, and to students in other schools.

References

Char, C. (2003) *Environmental Detectives: An Environmental Science Curriculum for Middle Schools, Year 2 Evaluation*. A report prepared for the Montshire Museum of Science. Montpelier, VT: Char Associates.