

# INTELLECTUAL ENERGY FLOW

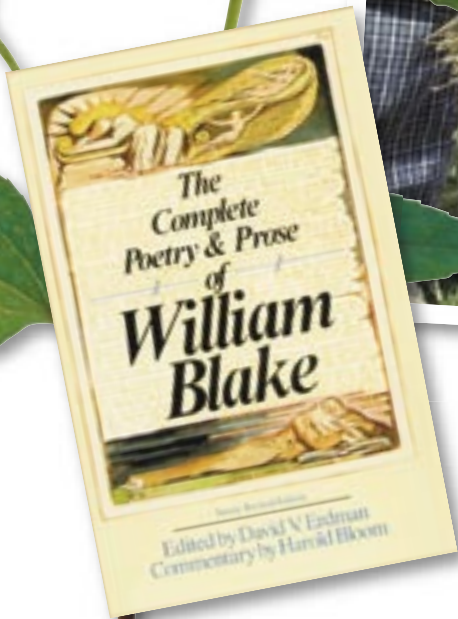


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— Amber Vogel and Christine Muth —

*An interdisciplinary  
approach to teacher  
professional development*

**A**n English teacher examines a sunflower under a hand lens. A visual arts teacher counts organisms in a plot of ground in the schoolyard. A science teacher considers the poet William Blake's "World in a Grain of Sand" (Erdman 1988). These are scenes from a half-day workshop titled Exploring New Environments, developed by the University of North Carolina at Chapel Hill's DESTINY Traveling Science Learning Program.

Exploring New Environments is a teacher professional development model based on the idea that teachers are also learners who thrive when given the means and encouragement to explore fresh intellectual worlds. Teachers can creatively use what they learn to increase their students' interest in and understanding of science.

### Supporting teachers

Established in 2000, DESTINY is a pre-college program that promotes equity of access to high-quality science education for all students. In rural and other underserved regions, our traveling science labs provide wet-lab experiences for students at schools where those opportunities are otherwise unavailable. Our professional development workshops for teachers provide lesson plans and classroom materials designed to empower teachers to meet the challenges that science education presents today.

Science teachers are DESTINY's primary focus. From the beginning, though, the program has sought to involve teachers of other disciplines in the process of science education. Initially, we concentrated on English language arts teachers, who teach critical thinking, analytical reading, and clear writing—skills that are particularly needed and valued in the sciences. We quickly discovered that English teachers, as well as teachers from other nonscience disciplines, were interested in attending our science-themed workshops and using our materials. Indeed, post-workshop evaluation showed that nonscience teachers responded even more positively to the workshops than did science teachers. Specifically, 7 science teachers and 1 nonscience teacher said they “agreed,” and 15 science teachers and 9 nonscience teachers said they “agreed strongly” with the following statement: “Interdisciplinary workshops have provided knowledge and/or skills that I consider to be valuable.” None of the participants said that they strongly disagreed, disagreed, or were uncertain.

When we set out to include nonscience teachers in our teacher training and support, we did not predict the high level of their enthusiasm—or that they would incorporate into their teaching the wet- and dry-lab science activities modeled in the workshops. Another unanticipated outcome was that many science teachers requested class sets of the books and used or adapted activities that we had intended for use in *nonscience* classrooms (Figure 1).

In addition, science and nonscience teachers began to collaborate on lesson plans such as those presented in the workshops. Our experience has shown that teachers across the curriculum are eager for materials and activities that will interest and help their students; reaching beyond apparent disciplinary boundaries appears to enhance the professional development experience and outcomes for teachers. Our

findings suggest that these science-themed interdisciplinary workshops are useful models.

### An interdisciplinary approach

DESTINY initiated its interdisciplinary approach with *Frankenstein's Fingerprints*, a module that deals with genetics, scientific discovery and ethics, and students' critical-thinking skills. Next, we taught a module called *The Evolution of Evolution*, focusing on scientific and cultural understanding of Darwin's insights, as well as thoughtful ways to hone students' discussion skills. Our third module—*Exploring New Environments: Using the Tools of Science and the Language Arts to Discover, Describe, and Understand Ecosystems*—tackles the complexities of ecosystems, reading and writing about nature with scientific insight, and students' observational skills.

Because it is important that professional development opportunities present ideas and materials that will be interesting and useful to teachers, we used a number of gauges for the effectiveness of *Exploring New Environments*. An external evaluator observed and assessed the first workshop, an exit survey enabled teachers to evaluate their experience as soon as each workshop ended, and an end-of-year survey asked participants to note which lesson ideas and materials they had used or adapted.

In 2003–2004, we piloted the module in workshops in three rural North Carolina school systems. Although the 50 teachers in the workshops were a self-selected group, they constituted a large portion of teachers targeted within these rural systems. The three workshops were targeted to environmental science, biology, and English language arts teachers at the secondary level, but participation was more diverse. In addition to science and English teachers, participants included visual arts teachers, media specialists, a speech/debate teacher, an exceptional children's teacher, a guidance counselor, and even a drafting teacher. A number of educators at the middle school and community college levels attended and subsequently put into action the lesson plans modeled.

Such broad participation may seem unusual, but participants from many disciplines enliven workshops as teachers share different perspectives on content and pedagogy. Importantly, the experience for science teachers does not appear to be diminished by the inclusion of nonscience participants, as these sample comments from exit surveys indicate: “Wonderful workshop that would really work in the real world!” And, “Best in years.”

### Teaching ecosystem ecology

We developed *Exploring New Environments* because teachers with whom we worked needed assistance in teaching ecosystem ecology. There were a number of reasons for this call for help. For instance, state and

**FIGURE 1****Overview of Exploring New Environments science lesson plans.****Pre-lab activities**

|             |                                                                                                                                                                                                                                                                                          |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Engagement  | Students prepare for an imaginary journey to deep sea hydrothermal vents.                                                                                                                                                                                                                |
| Exploration | Student groups examine photos and descriptions of the hydrothermal vent ecosystem and gather data on abiotic and biotic factors. To summarize their data, they create simple histograms by using sticky notes to represent single units.                                                 |
| Explanation | With the hydrothermal vent ecosystem as a starting point, teachers challenge students to explain contrasts to more familiar ecosystems.                                                                                                                                                  |
| Elaboration | Teachers introduce vocabulary and connect complex ecosystem processes to more familiar concepts. Creating diagrams and concept maps based on student-generated information reinforces for students that they already intuitively understand the basics of processes like carbon cycling. |
| Evaluation  | Students create a food web that includes themselves and shows the flow of energy and the cycling of materials among organisms and the physical environment.                                                                                                                              |

**Wet-lab activities**

|                       |                                                                                                                            |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------|
| Field expedition      | Student groups explore a 1 m <sup>2</sup> ecosystem within their schoolyard and gather data on abiotic and biotic factors. |
| Terrarium exploration | Student groups investigate a terrarium ecosystem in the classroom and gather data on abiotic and biotic factors.           |

**Post-lab activities**

|                    |                                                                                                                                                                                          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data analysis      | Students use the data they have gathered to create graphs, food pyramids, and food webs that can be compared to those based on data they collected from the hydrothermal vent ecosystem. |
| Role-play activity | Through role-play of these processes, students review the concepts of the flow of energy and cycling of materials in ecosystems.                                                         |
| Final evaluation   | Students design their own closed ecosystem (in written description, 3-D model, or actual mini-ecosystem).                                                                                |

national science education standards now emphasize environmental science, including ecosystem ecology, in the high school curriculum [National Science Content Standard C, including matter, energy, and organization in living systems and interdependence of organisms (NRC 1996, p. 181); and National Science Content Standard D, including geochemical cycles (NRC 1996, p. 186)]. As a result, many teachers are tackling this subject matter for the first time. But even experienced teachers find that some students have conceptual difficulties understanding the abstract and large-scale processes of ecosystems. Our hope was that an interdisciplinary approach to professional development in ecosystem ecology would help teachers make this challenging topic more engaging, understandable, and relevant for students.

Exploring New Environments includes a full set of science lesson plans (Figure 1). Pre-lab activities follow the 5E Instructional Model (BSCS 1993; Trowbridge, Bybee, and Powell 2000), and all activities promote active learning and address a range of student learning styles. During the workshop, teachers are able to experience

these plans much as their students will, by actually *doing* the activities described. This participatory approach is particularly effective in interdisciplinary workshops, where teachers often learn material outside their fields of expertise and are likely to ask many of the same questions students do.

We wanted to provide students with real ecological field experience and potentially inspire them to consider ecology and environmental science as exciting career paths. However, any wet lab we presented had to be teacher-friendly and based on the realities of the classroom. Because some teachers cannot take their students out to the schoolyard, we designed two options—a field expedition to a 1 m<sup>2</sup> ecosystem in the schoolyard and a terrarium exploration of an ecosystem in the classroom. Both activities give students a chance to use tools of professional ecologists (e.g., hand lenses and water-repellent, all-weather paper), work in groups to gather data on abiotic and biotic factors, and interact with a diversity of live organisms in the context of a functioning ecosystem. During the workshop, teachers experience both options.

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Throughout the workshop, teachers participate in writing exercises and small- and large-group discussions that weave language arts skills throughout the science content. We also give examples of relevant texts that

**FIGURE 2**

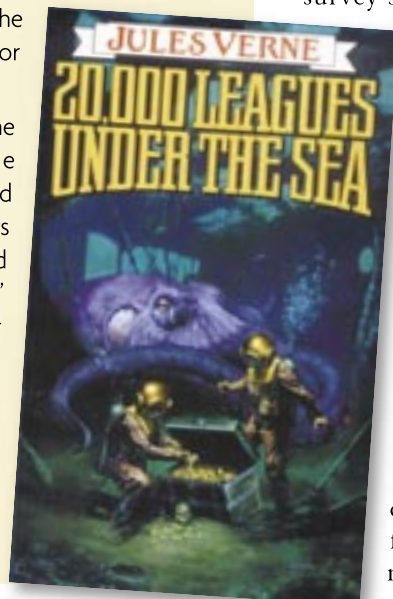
### Engagement activity: Imaginary deep-sea expedition.

One of the most exciting aspects of field ecology is the opportunity to travel to exotic locations and explore unusual ecosystems. This simple activity allows students to experience some of that excitement while forming basic scientific ideas about ecosystem structure and function. We describe a hydrothermal vent in the deep sea, but the activity can be easily adapted as an imaginary journey to almost any location in space or time.

We first ask our students to close their eyes and prepare to go on an imaginary journey. With their eyes closed, students are particularly focused and primed to use their imaginations. We then describe a place they will “explore.” We include a number of attention-grabbing details, such as poisonous gases, the absence of sunlight, and the smell of rotten eggs.

After our description is complete, we ask students to take several minutes to write down all the clues they can recall. Students share with the class the clues that they remember, along with their hypotheses about the mystery destination. Making individual records before sharing gives students time to organize their ideas. Finally, we reveal the destination by showing a photograph or short video clip.

Working in teams, students examine photos and descriptions of the hydrothermal vent ecosystem. Based on these pictorial and written records of the vents, students gather and record abiotic and biotic data. Students’ exploration of the hydrothermal vent ecosystem and the findings that they gather are important starting points for activities and discussions about ecosystem structure and function and can be used in nonscience classrooms for addressing themes such as travel, adventure, and discovery.



address requirements for English teachers in world, British, and American literature. For example, we discuss the potential for a dry lab such as the “Imaginary deep-sea expedition” (Figure 2) to serve as a pre-reading activity for a unit on Jules Verne’s *20,000 Leagues Under the Sea* or *Journey to the Center of the Earth*.

Our “Describe a sunflower” activity (Figure 3), which helps students hone observational skills and gives them experience using hand lenses, introduces the nature poetry of the English Romantics (e.g., Blake’s “Ah, Sun-Flower!”). Science and nonscience teachers responded favorably to these activities and ideas. For instance, a third of nonscience teachers responding to the end-of-year survey had used “Describe a sunflower” in their classes; a quarter of science teachers responding had used or modified “Describe a sunflower” in their classes. Because teachers’ input is crucial to successful professional development, we added Rachel Carson’s *Silent Spring* (1962) after teachers in the first workshop indicated a strong interest in this text; more than 40% of science teachers responding to our end-of-year survey assigned the book to their students.

### Professional outcomes

Workshops such as Exploring New Environments have the potential to garner nonscience collaborators for science teachers and also can encourage and prepare nonscience teachers to independently reinforce scientific content in their classrooms. The end-of-year survey showed nonscience teachers used or planned to use wet- and dry-lab activities and materials from the workshop in their classrooms. They used the “sticky bar graphs,” field expedition, terrarium exploration, group lab report worksheet, and hand lenses (Figure 1, p. 37). An English teacher wrote, “I really would like to use the description of the hydrothermal vents to introduce *20,000 Leagues Under the Sea*. I plan on using the carbon flow worksheets and then conducting a field lab on a sample plot of ground to introduce *Journey to the Center of the Earth*.”

Because there are often barriers to collaboration across disciplines (class schedules, end-of-course testing, and state-mandated curricula), we do not set this as a primary goal for professional development. Nonetheless, more than half of the teachers responding to

**FIGURE 3**

### Observation exercise: Describe a sunflower.



This simple exercise develops students' observational skills, helping them see the value of looking more closely at an object or an idea that they may have felt they already knew or understood. We use it to teach students the astonishing contrast between the relatively small amount of information with which one may start and the large amount of information one may accumulate after carefully examining an object or idea. We use sunflowers, but any interesting natural object will work. We use one object per group.

We group our students in clusters of four or five and instruct each group to “describe a sunflower.” They work together to list (in single words or in sentences) characteristics of a sunflower. They also make drawings from memory. In about five minutes, the groups run out of steam. At that point, we give each group the same instruction—“Describe a sunflower.” But this time we give each group a sunflower.

Then, the ideas come quickly; students use their senses to investigate the sunflower—the texture of its serrated leaves, the smell of its stem when broken, and the hues of its yellows, greens, and browns. Prying the flowers apart, students investigate and describe in greater detail. If we have hand lenses available, this is the time we distribute them. Each group's notes soon fill with concrete and vivid descriptors and observations rooted in careful observation. Sketching the flower can also help students focus their observations (Hobart 2005).

We use this as an engagement activity at the beginning of an assignment that requires careful observation, like the wet labs in Exploring New Environments. Our colleagues in English language arts and social studies use it to jump start the writing of descriptive papers, discussion of evidence or opinions, and reading of poems and other texts about the natural world.

our end-of-year survey stated that the interdisciplinary workshops had helped them to collaborate with a teacher outside their discipline. Most of the remaining respondents indicated that they planned to participate in such collaborations in the future.

Even when such collaboration is unfeasible, we find that the shared workshop experience enhances collegiality among science teachers and their counterparts in nonscience classrooms, and it promotes a schoolwide appreciation for science. A media specialist who attended two workshops, including Exploring New Environments, wrote on the end-of-year survey, “The workshops showed teachers many different ways to collaborate. They also helped teachers to realize that science does not stand alone but that it is connected to other disciplines. Our teachers need this.” An English teacher wrote, “Our teachers have become very excited about [these] workshops. It has allowed for open dialogue between disciplines that, in my years of teaching (12), I have not seen before. Some teachers forget how much fun learning can be *and* how relevant science can be to day-to-day teaching.”

Such comments reinforce our growing understanding that teachers thrive on and deserve access to information and inspiration from diverse sources, including content and colleagues from other disciplines. We hope our findings will encourage educational policymakers and funders to think beyond the strict compartments into which science teachers and their nonscience colleagues are so often placed, particularly at the secondary level. ■

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### Acknowledgment

Principal support for development of Exploring New Environments came from a Science Education Partnership Award through the National Institutes of Health (5R25RR016306), with supplemental support from GlaxoSmithKline and the Howard Hughes Medical Institute.

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