The 2004
Paul F-Brandwein
Lecture

Dr. Sheila K. Bennett
Professor of Natural Science
University of Maine at Augusta

Dr. Dean B. Bennett
Professor Emeritis
University of Maine at Farmington

3 April 2004
National Science Teachers Association
Atlanta, Georgia

REGARDING THE ECOLOGY OF SCIENCE EDUCATION

Connections to Environmental and Distance Education

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Introduction

PAUL F-BRANDWEIN (1912-1994)
AUTHOR, TEACHER, SCIENTIST, PUBLISHER, CONSERVATIONIST

"As teachers we enter the minds of others, thus we live in eternity. We help others live better lives, thus teaching remains a mercy."

—Paul F-Brandwein

Born an Austrian, Paul F-Brandwein emigrated to America before World War II. A profoundly modest and private man in his personal life, Paul F-Brandwein nonetheless came to be professionally at home at podiums and in laboratories, in classrooms, in the board rooms of the publishing industry, in scientific societies, and in educational associations. During the course of his long, distinguished, varied career, he worked productively as a scientist, an author, an educator (grade school to graduate school), an editor and publisher, and a conservationist. In the service of science and education, he delivered almost a thousand speeches to audiences worldwide.

Paul F-Brandwein's wide-ranging publications concern the humanities, science, and education. His first book of more than 50 in several languages, *Manual of Biology* (with Douglas Marsland [Holt]), appeared in 1939. His last book, *Science Talent in the Young Expressed Within Ecologies of Achievement*, was published posthumously by the National Research Center on the Gifted and Talented (Storrs, Connecticut). In addition, he was an author and/or coauthor of many research papers in science and science education, particularly in relation to the science shy, the science prone, the science talented, the gifted, and the disadvantaged. He also published widely in the humanities and the social sciences. (Note: Excerpted from a brief biography researched by Dr. Calvin W. Stillman.)

A MESSAGE FROM MARY BRANDWEIN
CHAIRWOMAN, THE PAUL F-BRANDWEIN INSTITUTE

Mary Brandwein

In 1997, I wrote in the first Paul F-Brandwein Symposium publication about the establishment of the Brandwein Institute. I explained how my husband, Paul F-Brandwein, and I, with our friend, partner, and colleague, the late Evelyn Morholt, had planned for more than twenty years to establish the Rutgers Creek Wildlife Conservancy in Greenville, New York. We incorporated the Brandwein-Morholt Trust as a nonprofit organization just before Paul died in September 1994.

The next year, Evelyn suggested that we talk to Jack Padalino, then the president of the Pocono Environmental Education Center, or PEEC. Jack had known Paul who was one of PEEC's first trustees, and they shared similar views on the environment, conservation, and education.

Jack agreed to help and brought Bill Hammond of Florida and Alan Sandler of Washington, D.C. to Rutgers Creek to analyze its possibilities for conservation education. Other experts–botanists, environmentalists, a water quality specialist, and an ornithologist–visited and admired the property's beauty, flora, fauna, and waterways. Bill Olson surveyed the conservancy's vascular plants and established our herbarium. Members of the New Jersey Mycological Society, led by Raymond Fatto, conducted forays and discovered 217 species of fungi. Jack also brought international visitors: Russian teachers, children, and scientists. Junior Natural Scientists visited and helped Fred Tetlow set out 10 bluebird boxes.

In 1996, the advisors decided unanimously to locate the Paul F-Brandwein Institute on the grounds of the Conservancy. The Institute was born–a joint effort of the Brandwein-Morholt Trust and PEEC. Advisors became board members, an endowment was established to perpetuate an annual Brandwein lecture series, and the Institute convened 17 scientists and teachers to Milford, Pennsylvania as newly-selected fellows. In November 1997, the Institute fellows met for the first Paul F-Brandwein Symposium.

The dream has come to fruition. More plans are being made for the future. The Board, the Fellows, and I are committed to Paul's dream of a viable Institute at the Conservancy serving children, teachers, and scientists interested in sustaining a healthful and healing environment.

A MESSAGE FROM JOHN (JACK) PADALINO,
PRESIDENT, THE PAUL F-BRANDWEIN INSTITUTE

John J. Padalino

It is our vision that Paul Brandwein's dream of a viable conservancy serving children, teachers, and scientists interested in and committed to a healthful, healing, and sustainable environment will continue to bear fruit through the work of the Institute.

The Institute continues to conserve the ecosystems and habitats as well as their constituent flora and fauna within the Rutgers Creek Wildlife Conservancy, a miniconservancy of generalized deciduous woods interlaced with tributaries feeding Rutgers Kill in Orange County, New York.

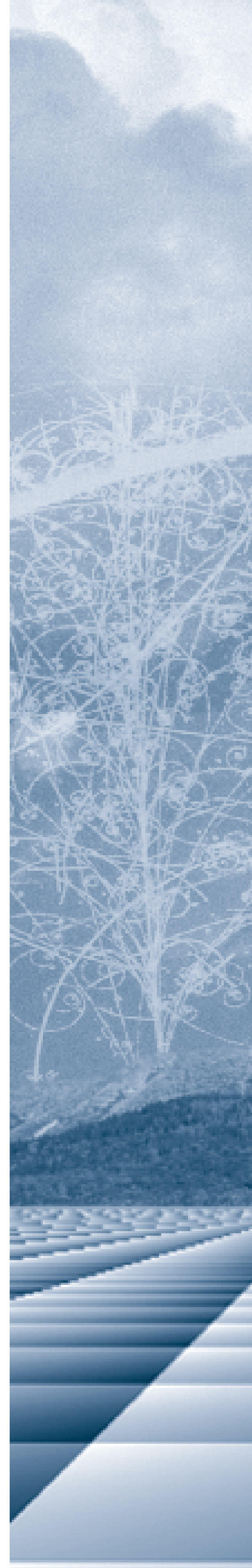
Focused on research in teaching and learning, the Institute and its Fellows use the Conservancy and Mary Brandwein's land for instruction and place-based learning. Land use continues to be devoted to teaching research practices of selected biological and environmental sciences to teachers and students inclined to explore them. The Institute has been developing formal teaching and learning experiences in conservation of eastern deciduous ecosystems. Teachers and students prone to and who wish to conduct research are welcome to use the Brandwein lands as an outdoor learning laboratory.

It was Paul who noted: "Once equality of educational opportunity is safeguarded for all, the young can be trusted to fulfill their special powers in pursuit of excellence. Thus both difference and likeness will become precious . . . when they do, we shall outwit time." Therefore, over the past eight years, the Institute has become a teaching facility given over to the education of teachers and students in the principles and practices of conservation, long-term ecological research, and sustainability. The Institute's mission is to advance teaching, learning, and innovation for the benefit of all people. Our goal is to nurture a family of educators and scientists who explore place-based science as an avenue to innovation.

The Institute will continue its work by focusing on ten central priorities: (1) it serves as a national center for modeling techniques in teaching conservation and local, long-term ecological research; (2) the Institute serves teachers, students, and the surrounding community; (3) it will continue its base-line studies of the miniconservancy at the Rutgers Creek Wildlife Conservancy and Mary Brandwein's lands; (4) it gives teachers on-site opportunities for professional development of varying durations; (5) time frames for work at the Institute vary with the projects and programs offered; (6) teachers, administrators, and curriculum developers are provided opportunities to create instruments to measure field-based learning as well as evaluate alternative assessments and performance-based examinations; (7) the Institute advances certain scientific priorities to enhance teaching and learning science through invitation to investigation; (8) it advocates certain methods of teaching and learning, again based on invitations to conservation and field-based investigations; (9) the Institute holds to certain practical goals; and (10) institute projects continue to employ state-of-the-art technologies to monitor environments as well as organize and analyze data from field studies.

Broadening the scope of the Institute will be further accomplished by advancing sustainability through encouraging mentors who can reach out to others, and by (1) convening in fall 2005 the Conservation Education Summit: Forty Years Later, focused on the philosophy and techniques of teaching conservation; (2) expanding the program strategically through project selection focused on miniconservancies over the next three to five years; (3) maintaining communication between and among fellows, directors, and constituents through our listserver; (4) contributing to the growth of the Mary Brandwein Endowment; (5) maintaining our interactive web site based on discussion of reality-based problems; and (6) perpetuating the Paul F-Brandwein Lecture Series.

Our work honors teachers and instruction, keeping in mind and close to our heart Paul Brandwein's admonition: "The value of a person's advice about teaching is inversely proportional to the square of the distance he or she is from the classroom."



Lecture

REGARDING THE ECOLOGY OF SCIENCE EDUCATION: Connections to Environmental and Distance Education

Dr. Sheila K. Bennett and Dr. Dean B. Bennett

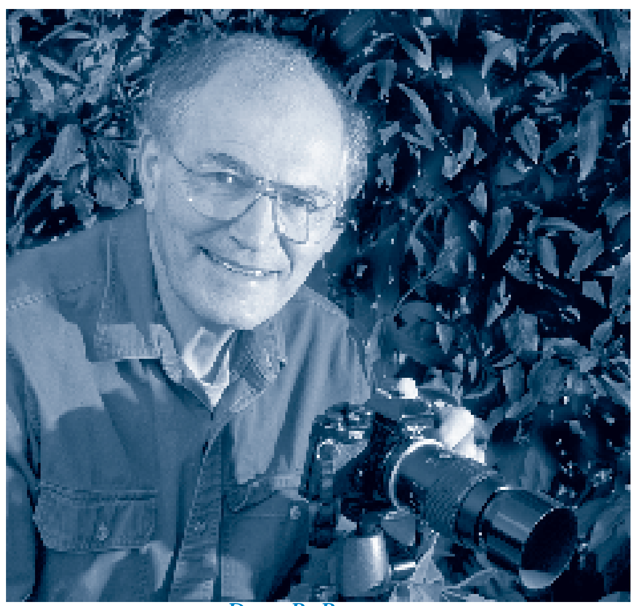
Abstract

Paul F-Brandwein was a visionary who looked at education broadly. He left us with an insightful view of the ecology of education in which he identified three ecological systems: school-family-community, postsecondary, and cultural. The first part of this lecture, by Dean B. Bennett, examines Brandwein's ideas related to environmental education and explores the relationship of environmental education with science teaching in the K-12 school-family-community ecosystem. Focusing particularly on the middle-secondary level, evidence suggests that the goals of environmental education, since their emergence in the late 1960s, are today strongly evident in science curricula, instructional resources, educational assessment, and teacher education. But the author points out that more must be done and provides some fundamental suggestions. The second part of the lecture, by Sheila K. Bennett, examines the role of distance education in the teaching of science in the postsecondary ecosystem and addresses its value as a viable tool in promoting scientific literacy. The lecture focuses on a successful statewide, interdisciplinary laboratory science course delivered by interactive television, the Internet, and computer network. Now in its ninth year, the course reflects Brandwein's thinking about effective classroom teaching and is based on national standards for scientific literacy.

Environmental Education and Science Education

Dean Bennett

First, we would like to express our appreciation to the Paul F-Brandwein Institute for this opportunity to explore the relationship of two educational movements with science education. The first is the educational movement called environmental education. The second is distance education. Today, both are highly influenced by technology and offer challenges and rewards for science teachers, students, and society. And both reflect the teachings of Paul F-Brandwein.



Dean B. Bennett

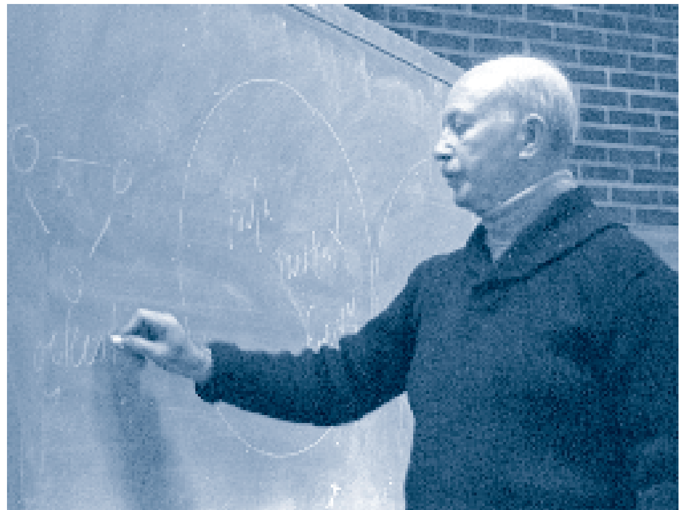
I first met Paul Brandwein in 1970 at the University of Michigan's School of Natural Resources. He spoke to a small group of us who were graduate students under the direction of the late William (Bill) Stapp. I was in my mid-thirties and working on a PhD in conservation and resource planning with an emphasis in environmental education, then an educational movement still in its infancy. Paul was grounded in years of experience in science, conservation, and education as a teacher, researcher, curriculum innovator, and writer, and I was eager to learn. I remember being impressed with the breadth and depth of his understanding of education. He was an extraordinary speaker who knew how to make contact with his audience, and he drew us in with his insight, wit, and enthusiasm with dashes of humor and an occasional mischievous grin. I had no idea that I would one day be privileged to work with this visionary educational leader and that his work and philosophy would have such an influence on my own career.

Paul Brandwein understood the importance of environmental education and its goal of motivating citizens to environmental action, for when I first met him at that meeting in 1970, he had served twelve years as education director and later co-director of the Pinchot Institute of Conservation Studies at Grey Towers in Milford, Pennsylvania. He was well aware of the environmental problems and issues facing our nation and the necessity of our citizenry to become motivated and active in helping to resolve them. He clearly understood the fundamental principles and implications of environmental education as it was being defined. Its interdisciplinary nature and focus on concepts and values had already appeared in his curriculum contributions. As early as 1964 in a lecture given at a conference for high school teachers of science and mathematics, he had laid out the conceptual structure of what would become a popular elementary and junior high school science curriculum, *Concepts in Science*, based on ecological principles and the effects of human activity in modifying the environment (Brandwein, 1968). By 1970, he had published *The Social Sciences: Concepts and Values*, which embraced an environmental emphasis, and was completing his monograph *The Permanent Agenda of Man: The Humanities*. In this he conveyed the idea that a curriculum is a perspective on human values in which a child could come to understand her or his environment as a whole, seeing it as a home in which the essential values are truth, beauty, justice, love, and faith (Brandwein, 1971).

Through the decade of the 1970s and into the 1980s, the environmental education movement grew rapidly. Congressional legislation enacted during the 1960s and early 1970s played no small role in its growth. The Elementary Secondary Education Act of 1965 provided funding for innovative educational projects in public school systems, and hundreds of these were pioneer programs in nature study, outdoor education, conservation education, and environmental education. The appearance of these programs was not unrelated to the environmental mood of the nation. This was a time of landmark environmental legislation: the Wilderness Act, the National Wild and Scenic Rivers Act, the Endangered Species Act, and numerous others to protect our air and waters. Professional education organizations, such as the Conservation Education Association, which later merged with the North American Association for Environmental Education, also experienced growth. State educational agencies drew up environmental education plans and created state directors, curriculum consultants, and coordinators for environmental education. Many of these new career opportunities were filled by science teachers. In the mid-1970s, Bill Stapp was appointed the first director of Unesco's environmental education program and presided over the program's first international conference. It was during these exciting years that my own involvement in environmental education brought me into contact with William (Bill) Hammond, director of the Lee County, Florida environmental education program and John (Jack) Padalino, president of the Pocono Environmental Education Center. In the early 1980s, the three of us and others joined with Paul Brandwein to explore his vision for the Human Habitat Study, a program for schools based on the principles of environmental education.

Paul's idea for the Human Habitat Study reflected his thinking about the concept of ecosystem and its potential as a unifying theme for understanding schooling and education. Two of Paul's books, in particular, communicate his view of the relationship of ecology to education: *Memorandum: On Renewing Schooling and Education* (Brandwein, 1981) and *Science Talent in the Young Expressed Within Ecologies of Achievement*, published in 1995, a year after his death. In the latter, Paul wrote that "the ecology of education comprises three intereffective ecosystems–that of the family-school-community, the culture, and the postsecondary systems. When these three ecosystems interact harmoniously, they form an ecology of achievement that offers all the young opportunity for their special endowments . . . to flourish" (Brandwein, 1995, p xi).

Thus, Paul laid out for us a context in which we can view education. As a science teacher and environmental educator who has worked in all three educational ecosystems in a career spanning more than forty years, I would like to discuss changes in the relationship between environmental education and science education in the schools. From the outset, dating back to 1967 and my initial internship in Bill Stapp's conservation education program in the schools of Ann Arbor, Michigan, I viewed environmental education not as a separate subject area but as a curriculum and instructional emphasis integrated into the school's existing disciplines. Its appearance in school curricula is a clear example of the interaction between our family-school-community and cultural ecosystems. It evolved from the interconnectedness of culture and environment and associated problems and issues.


Paul F-Brandwein

The changing relationship between environmental education and science education in the schools can be illustrated by comparing two earth science textbook programs produced nearly forty years apart. However, we should not look exclusively at curriculum and instruction as indicators of a changing relationship. In keeping with Brandwein's view that the family-school-community ecosystem is interconnected with postsecondary and cultural ecosystems, three critical factors will also be examined briefly: instructional resources, educational assessment, and teacher education.

When I taught earth science in the 1960s at grade nine, I received a new textbook produced by the Earth Science Curriculum Project, which evolved in the post-Sputnik era. Titled *Investigating the Earth*, it was published under sponsorship of the American Geological Society with support from the National Science Foundation (NSF) (Earth Science Curriculum Project, 1968). I was introduced to this book at an NSF summer institute at the University of Southern California. Hundreds of scientists and educators worked more than three years to prepare it. Among its 594 pages, only four pages were devoted to the topic "Man and his environment." It is evident from these four pages that environmental problems and issues and their significance were only beginning to be understood. Only brief mention was made about the dumping of wastes into our waters and into the atmosphere. More space was allotted to erosion and contour plowing. We were still a long way from recognizing that we could alter the global climate and pollute the oceans or that acid rain and mercury pollution would become serious problems. The word *pollution* did not even appear in the index. Instruction was almost entirely oriented to laboratory and reading activities. Few if any of the activities suggested first-hand experiences in the field outside the classroom and none included the investigation of environmental problems. There was, however, recognition that instruction and curricular content fused when the processes of science were to be learned; that is, the student learned the skills of scientists by practicing how they worked.

A clue to the lack of an environmental education emphasis in this earth science program can be found in a 1966 study of twenty-three science programs at elementary and secondary levels, prepared by the Association of Supervision and Curriculum Development (ASCD). The author found that the objectives of these programs often cited the need to purify science subject matter by eliminating technology and the application of principles to practical problems. Interestingly, the author, however, raised the question of how pure science programs should be, noting that teachers took numerous trips to water purification plants, factories, and agricultural and game management projects (Haney, 1966).

Today, more than thirty years later, the same publisher still produces an earth science textbook for middle and high school science students. A comparison of the two textbooks illuminates striking differences. Rather than four pages devoted to humans and their environment, the new text has an entire chapter devoted to resources and the environment that includes a section on environmental issues. Additional chapters look at the earth as a system, human impact on the atmosphere, and issues related to climate and civilization, soil protection, flood prevention, dam removal, and groundwater pollution (Spaulding and Namowitz, 2003).

Instructional resources to which earth science students were directed by my 1960's textbook were limited to suggested readings and periodicals at the end of each chapter. Today's version directs students to current and reliable online investigations, visualizations, data centers and links, and local resources directly related to the book's chapters. Students investigate a wide range of environmental topics, problems, and issues, including, for example, use of satellite images to analyze environmental health and protection of parks and other natural areas (Classzone).

The area of assessment of science learning outcomes also gives a clue as to how much environmental education is now a part of current science curriculum and instruction at elementary and secondary levels. For example, objectives of environmental education are reflected in the content area standards of the 1996 publication *National Science Education Standards* by the National Research Council. I refer particularly to the science and technology standard and the science in personal and social perspectives standard (National Research Council, 1996). In my own state, the Maine Legislature in 1996 adopted a comprehensive, statewide assessment system, which includes statewide testing of learning results at grades 4, 8, and 11 and requires that the test scores for each school system be published in the newspaper. Indicators of environmental learning appear in the science and technology content area. This area includes thirteen standards, two of which are of special interest to environmental education–ecology and implications of science and technology. The "implications" standard is especially relevant to our discussion and includes in its description the following statement: "By assessing the impacts of technological activity on the environment, students will develop their own sense of global stewardship." One of several performance indicators for this standard at the secondary level is the following: "Students will be able to evaluate the ethical use or introduction of new scientific or technological developments" (Maine Department of Education, 1997, pp 64, 77).

Postsecondary teacher education has also experienced a change in environmental education emphasis. During 1967 and 1968, a study of programs for the preparation of science teachers, conducted by the Harvard Graduate School of Education, showed that the social implications of science ranked low among content emphases for both secondary and elementary courses. Interestingly, the textbook most mentioned was *A Sourcebook for the Biological Sciences* by Paul Brandwein and others (Newton and Watson, 1968).

The textbook that I used in my middle and secondary science methods course more than thirty years later included a strong interdisciplinary emphasis. It contained an entire chapter devoted to the Science, Technology, and Society (STS) program philosophy. The author explained that "the central premise of STS teaching is to help students develop the knowledge, skills and effective qualities to take responsible citizenship action on science and technology oriented issues" (Hassard, 1992, p 173). He noted that both environmental education and STS programs are problem and issue-oriented, require interdisciplinary thinking, connect science to society, stress global awareness, incorporate values clarification, and engage students in action projects.

In summary, although my investigation was limited, I believe one can say with confidence that science education is today much more environmentally oriented than it was during the mid-to-late 1960s. This was evident in a comparison of two textbook programs, in the kind and availability of instructional resources, in the development of standards and assessment programs, and in teacher education. But is this enough? Should we be satisfied and complacent? I suggest not.

Unfortunately, many serious environmental problems still exist, some are still growing, and more are threatened. This situation continues to pose a difficult challenge to educators who believe that the development of understandings, skills, and attitudes will transfer to corrective decision making and action. As teachers of science, I believe we have an opportunity and a responsibility to assist in solutions.

As I analyze our years of experience in teaching environmental education as a part of science education, I see three fundamental principles that can help guide our future teaching in this area:

1. Stress that humans are an integral part of nature, emphasizing that the human species is one with the *rest* of nature and, therefore, what humans do to nature they do to themselves.
2. Provide firsthand, intimate field experiences in natural areas that increase an understanding and a valuing of nature's inherent beauty, integrity, and resiliency and our dependence on the components and processes of ecological systems.
3. Advocate for the preservation of wildness in nature to provide places for such experiences and for the protection of species and ecosystem diversity.

To conclude, we must use our scientific understanding of ourselves, the rest of nature, and our technology to correct and avoid the environmental mistakes of the past. Paul F-Brandwein saw clearly our connections to the natural world and to each other and described them in terms of ecology. Furthermore, he said: "We are all affected by the powerful partnership of science and technology; these ramify every aspect of life" (Brandwein, 1968, p 2).

Distance Education: Making Connections in the Postsecondary Ecosystem

Sheila K. Bennett

Sheila K. Bennett

It was 1968 when Paul F-Brandwein recognized the ramifications of the partnership of science and technology. Today, when we consider just one of the consequences, that of computer technology, we know how prophetic he was. His attention to the partnership continued in his later works. In *Memorandum: On Renewing Schooling and Education,* he addressed the course of innovative classroom technologies and programmed instruction, and in a document published in 1995 after his death, he referred to the impact of computer-assisted instruction: "This technology can stimulate children to undertake inquiry beyond expectations" (Brandwein, 1995, p 74). Now we ask how we can extend that impact to an older population, that of the postsecondary ecosystem.

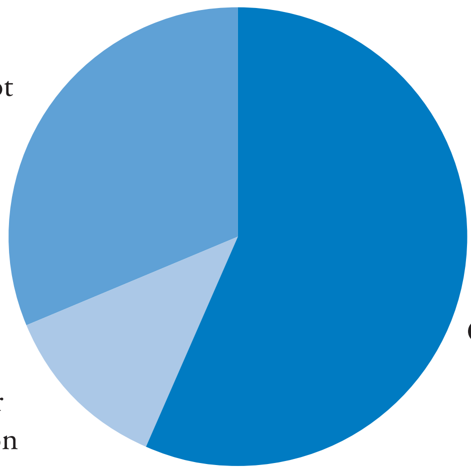
Can the technology of distance education stimulate inquiry and advance scientific literacy in our college and university students? Two headlines from last summer's news have import in contemplating an answer to this question: from the Associated Press–"Distance learning booming in US" (Giegerich, 2003) and from *The Chronicle of Higher Education*–"National Tests of College Students' Learning May Be on the Way, Policy Analysts Say" (Selingo, 2003). Accountability and rising college costs are driving the latter, while the integration of the Internet into the busy lives of many people is leading the upsurge in enrollment in online courses and programs. How can we ensure the educational integrity of distance learning, assess its effectiveness, and make it accountable? How can science educators take advantage of the technology to promote an understanding of our natural world?

These are questions which have been asked in various ways and with varying intensity over the last twenty years. The idea of distance education–instructional television, video conferencing, and the Internet–was not readily embraced by college faculty. Some of my pioneering colleagues bear the scars from their introductory battles. The path to acceptance of distance education as a viable educational tool is not unlike that of extraordinary ideas in science, Wegener's Continental Drift, for example. The German philospher, Schopenhauer, described this torturous route thus:

> Whenever a new truth enters the world, the first stage of reaction to it is to ridicule, the second stage is violent opposition, and in the third stage, that truth comes to be regarded as self-evident.
>
> Arthur Schopenhauer (1788-1860)

Refinements in technology, sophistication in using technology, and recognition of the need for standards by the accrediting agencies–along with faculty success and satisfaction–have contributed to a progression of distance education toward Schopenhauer's third stage. Faculty in Maine who once had to be coerced into teaching on instructional television (ITV) are now clamoring for air time and turning to online teaching when their requests for TV time slots go unheeded. A survey by the National Center for Education Statistics found that during the academic year of 2000-2001 56 percent of all two-year and four-year, Title IV-eligible, degree-granting institutions offered distance education courses for any level or audience (See Figure 1) (Waits and Lewis, 2003, p 4). Science educators at the postsecondary level can participate in this progression by insisting on programs and courses that further scientific literacy, whether offered in a traditional manner or at a distance.

Figure 1. Percentage distribution of 2-year and 4-year Title IV degree-granting institutions, by distance education program status: 2000-2001.



NOTE: Percentages are based on the estimated 4,130 2-year and 4-year Title IV-eligible, degree-granting institutions in the nation. Detail may not sum to totals because of rounding,
SOURCE: U.S. Department of Education National Center for Education Statistics, Postsecondary Education Quick Information System, "Survey on Distance Education at Higher Education Institutions, 2000-2001," 2002.

At the time that distance education was making its way into the postsecondary arena, science educators were heeding the report prepared by the National Commission on Excellence in Education, *A Nation at Risk: The Imperative for Educational Reform* (1983). Spurred on by the American Association for the Advancement of Science (AAAS) in its report *Science for All Americans* (1989), the National Research Council of the National Academy of Sciences developed standards based on consensus and research which provide for an education system that prepares a scientifically literate society. The National Science Teachers Association (NSTA) recognized the important role of colleges and universities in that education system with its publication *College Pathways to the Science Education Standards*:

> The lessons and experiences we provide will be passed to future generations by way of our majors who enter fields of science and technology and by way of those nonmajors who make policy and those who approve it. (Siebert and McInstosh, 2001, p ix)

A prominent example of recent policy making affecting science education is the No Child Left Behind Act of January 2002. It emphasizes the important responsibilities of college faculty by requiring that all states ensure that every core-subject classroom teacher is certified, holds a bachelor's degree, and has demonstrated competencies in his or her teaching area (Peterson, 2003).

By applying the *National Science Education Standards* to the college level, our graduates can benefit from the considerable effort put forth in developing the K-12 standards, and the entire web of science education ecosystems can move towards the goal of a scientifically literate public, creating what Paul Brandwein called a "synergism of ecosystems"(Brandwein, 1995, p 10). Connections at the postsecondary level which contribute to this synergism can be found in the core curriculum or general education requirements, and in the definition and assessment of student outcomes to inform decisions about the core curriculum and science programs. In both instances, the connections apply equally to the traditional classroom/lab format or in a distance instructional-technology mode. In fact, Peter Elwell, senior associate at the National Center for Higher Education Management; Peggy L. Maki, director of assessment at the American Association for Higher Education; and Charles M. Cook, director of the New England Association of Schools and Colleges' Commission on Institutions of Higher Education, indicate that distance education is leading the way in moving higher education toward outcomes-based assessment (Carnevale, 2001).

The Associated Press article mentioned earlier suggests that national and regional accreditation agencies certifying academic quality are recognizing distance programs. Those same agencies are instrumental in promoting standards that encourage evaluation of learning outcomes to show effectiveness of the institution. Science faculty and education faculty have the opportunity to influence the definition and assessment of student outcomes. The *National Science Education Standards* provide a foundation for this effort. Should national testing be extended to the college level, measurable student outcomes based on the *National Science Education Standards* would be in place.

If scientific literacy includes an understanding of the nature of the scientific enterprise, that is, an appreciation of "how we know" what we know in science, is distance education an appropriate instructional tool? Can science education at a distance meet the standards requiring scientific inquiry to develop this appreciation? Today, distance education includes at least ten primary modes of instructional delivery to remote sites. These range from two-way video with two-way audio to Internet courses, CD-ROM, and multimode packages (See Table 1) (Waits and Lewis, 2003, p 40). Can a lab science course take advantage of one or more of these technologies and meet the *National Science Education Standards*?

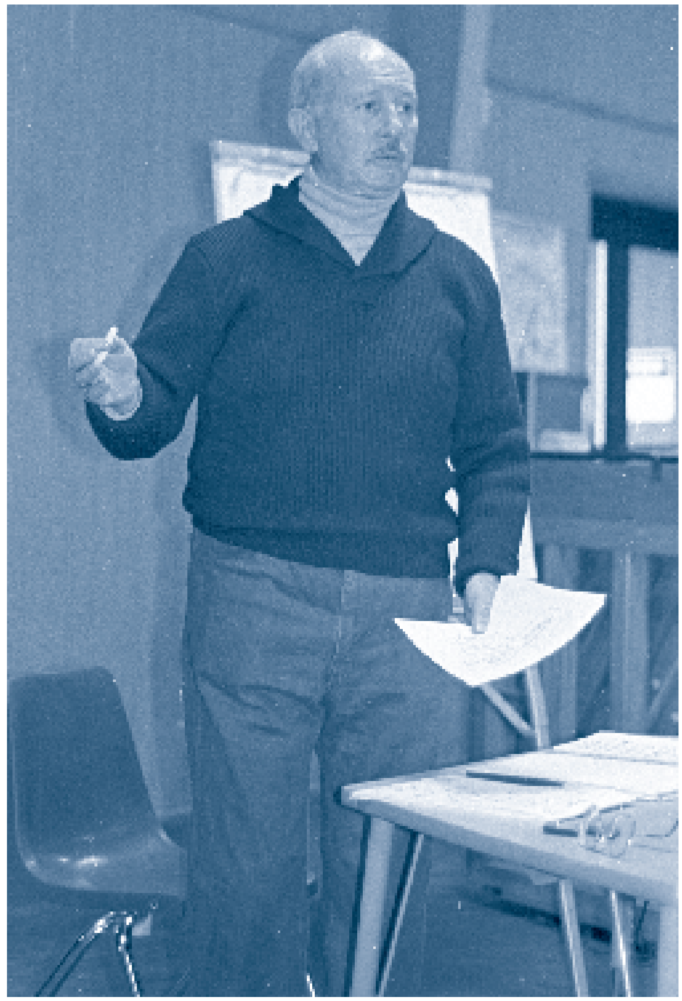
Table 1. Percent of 2-year and 4-year Title IV degree-granting institutions offering any distance education courses, by primary technology for instructional delivery for distance education courses, and by institutional type and size: 2000-2001.

Institutional type and size	Primary technology for instructional delivery										
	Two-way video with two-way audio[1]	One-way video with two-way audio	One-way live video	One-way pre-recorded video	Two-way audio transmission	One-way audio transmission	Synchronous Internet courses[2]	Asynchronous Internet courses[3]	CD-ROM	Multi-mode packages	Other technologies
All institutions	51	11	8	41	9	11	43	90	29	19	3
Institution type[4]											
Public 2-year	60	13	9	57	7	11	40	95	30	21	2
Public 4-year	80	15	13	40	11	10	55	87	29	29	5
Private 4-year	22	6	4	24	11	12	35	86	23	11	3
Size of institution											
Less than 3,000	39	6	4	29	8	9	36	87	22	11	2
3,000 to 9,000	57	10	10	49	10	10	46	92	31	22	3
10,000 or more	70	26	17	61	12	18	56	95	43	36	5

[1]The wording in the questionnaire was "Two-way video with two-way audio (i.e., two-way interactive video)."
[2]The wording in the questionnaire was "Internet courses using synchronous (i.e., simultaneous or "real time") computer-based instruction."
[3]The wording in the questionnaire was "Internet courses using asynchronous (i.e., not simultaneous) computer-based instruction."
[4]Data for private 2-year institutions are not reported in a separate category because too few private 2-year institutions in the sample offered distance education courses in 2000-2001 to make reliable estimates. Data for private 2-year institutions are included in the tools and in analyses by other institutional characteristics.
NOTE: Percentages are based on the estimated 2,320 institutions that offered any distance education courses in 2000-2001. Percentagees sum to more than 100 because institutions could use different types of technologies as primary modes of instructional delivery for different distance education courses.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Postsecondary Education Quick Information System, "Survey on Distance Education at Higher Education Institutions, 2000-2001," 2002.

To begin to answer these questions and to illustrate a distance education connection to the postsecondary science education ecosystem, I will describe a Maine science education experience which began as an act of desperation and has succeeded, in large part, because of the recognition by the AAAS of the need for a guide for science faculty in promoting scientific literacy. In the early 1980s, the University of Maine System began to address the need for access to higher education in a state so sparsely populated that there are areas in the forested north where moose and bear outnumber humans. Many in Maine are place-bound adults who do not have the luxury of living on or near one of the seven university campuses. Only twenty-four percent of Maine's population have a bachelor's degree, seven percent less than the New England population as a whole.

To provide access to this place-bound population, the University of Maine at Augusta (UMA) began experimenting with some televised courses in the early 1980s. These were not interactive and did not fulfill Paul Brandwein's requisites for TV instruction: "Instructed learning should permit and, indeed, encourage interruption of the lesson, should make time for the immediate response and participation of the students—as the best classroom instruction does"(Brandwein, 1981, pp 44-45). The effort failed, and the faculty breathed a sigh of relief.



Paul F-Brandwein

By 1989 advances in technology prompted renewed efforts to increase access. Federal and state funding were used to create an instructional television network as a means of providing delivery of off-campus associate degrees. Fiber optic cable and a microwave tower network now connect over ninety receive sites around the state, including islands off the coast. Each receive site is equipped with a TV monitor, VCR, telephone, fax, copy machine, and computer. Importantly, the lesson can be interrupted. Students can see and talk with the instructor during the broadcast. The nexus of the system continues today with over 18,800 credit hours generated by ITV (10,700 credit hours) and online courses (8,100 credit hours) in the 2003 fall semester.

In 1989, the idea of obtaining a higher education degree via instructional television was revolutionary and subject to intense criticism. The integrity of a course was called into question, the pedagogy deemed inferior, and any degree obtained in this manner was subject to ridicule. Science faculty assumed we would be exempt from the wrath of our peers since it would be impossible to offer a lab science in this manner! Ultimately, we realized that the system was being promoted as a way to obtain a degree without ever having to come to a campus, and many associate degree programs at the time required a lab science. It wasn't long before the science faculty were charged with the task of developing a lab science course that could be offered at a distance.

The situation called for a quantum leap in perspective on the part of colleagues who are products of a traditional education, on the part of administrators who may not be aware of the constraints encountered in any lab science course, let alone one at a distance, and on the part of ITV students who expected a traditional two-hour lab and who needed reassurance that their degree would not be viewed as inferior to one obtained in a traditional manner. Furthermore, since each of us on the faculty was oriented to a lab with four walls and equipment appropriate to a particular science discipline, the assignment was daunting. This is a barrier that remains today, but innovation and creativity, two important characteristics of scientists, provide for an increasing experimentation in overcoming it. (See Carnevale, 2002, 2003a. 2003b; Carr, 2000a, 2000b; Davenport, 2001; Forinash and Wisman, 2001; Lucklow, 2002; Winer et al., 2000).

Great motivation to scale the barrier came when the UMA science faculty realized there was a significant opportunity on our doorstep to change attitudes about science in a large population of Mainers that we would never see on our campus. Think how much corporations pay for a few seconds of TV air time to influence behavior, and we were being granted six hours of air time per week for a fifteen-week semester! Cognizant of the raging criticism of the three-credit lecture courses offered on ITV, we were well aware of the need to have a very sound foundation for lab science at a distance. The AAAS publication, *Science as a Liberal Art* (AAAS, 1990), offered a guide to that foundation. We established goals and objectives as recommended by the report for all our lab sciences, whether taught in a traditional science lab or at a distance and regardless of the science discipline–physics, biology, chemistry, or geology.

Next, we addressed the problem of how to "teach science as science is practiced" (AAAS, 1990) at a distance. The labs associated with our traditional introductory biology, chemistry, physics, and geology courses were inappropriate for distance delivery. Further, the course would need to focus on ideas that transcend disciplinary boundaries, in keeping with the AAAS recommendations to foster an understanding of the intellectual relationships among all the disciplines in science. Lab investigations were needed to support and extend these ideas. Recognizing that the computer is integral to the practice of science, it became our major equipment focus, creating the foundation of a *collaboratory,* a term coined by William Wulf of the University of Virginia to describe a way in which information technology is used to support methods of scientific inquiry:

> [It is] a center without walls, in which the nation's researchers can perform their research without regard to physical location—interacting with colleagues, accessing instrumentation, sharing data and computational resources, accessing information in digital libraries. (Wulf,1993, pp 854-855)

Today, the computer program, Blackboard, is utilized as the communication tool.

To further simulate the work of scientists, students work in teams, communicating their lab results via the computer, and working together to prepare lab reports in a research article format requiring tables, graphs, and statistical analysis of the team's results. Teams are typically composed of four students enrolled at sites in the same region of the state so that comparisons of results can be made across the state, as done in our ground-level ozone investigation. Coastal regions are notorious for high levels of ozone in the summer (Maine Department of Environmental Protection). Comparison with data collected by the Maine Bureau of Air Quality can be made through an external link set up in the course area of Blackboard. Materials for the lab investigations are purchased in a lab kit that also contains a student manual that provides background and directions for the labs.

Since the first offering of the course via ITV and computers in 1994, SCI 120, Introduction to the Natural Sciences, has become a regular fall-course offering for 100 students enrolled at receive sites around the state and has been adapted as a traditional lab science for a spring-semester offering. The three goals of the course adopted in 1993 reflect both the AAAS recommendations and the national standards:

1) Students will be familiar with the values that guide the scientific enterprise, its methods of inquiry, and the ways results are communicated;
2) Students will develop an awareness of ideas that transcend science discipline boundaries;
3) Students will have an acquaintance with the historical and contemporary context of science.

The interdisciplinary content, including statistics and expository writing, as well as the physical, biological, and earth sciences, advances the recommendations of the AAAS, NSTA, and the National Research Council's science education standards and recommendations of its recent report, *BIO 2010: Transforming Undergraduate Education for Future Research Biologists* (2003). When the delivery tool is in real time with two-way communication, such as ITV, compressed video, or synchronous online, the lesson can be interrupted, thus fulfilling a Brandwein prerequisite for exemplary instruction.

Finally, this lab science at a distance contributes to the synergy of educational ecosystems by connecting the postsecondary ecosystem with both the K-12 ecosystem and the cultural ecosystem. It evolved from the cultural need for access to higher education by a place-bound, dispersed population. Nontraditional older students can continue to hold down one or two jobs and care for their children and spouse while working towards a degree. This access to higher education allows them to become role models for their children, a further connection of ecosystems. With attention to a solid foundation, such as the *National Science Education Standards*, there is an opportunity for science educators to advance the goal of a scientifically literate public through a distance delivery mode.

Both environmental education and distance education form connections among the three ecosystems identified by Paul F-Brandwein. They contribute to the synergy of science education in helping to achieve scientific literacy for all. This way of thinking about education is but one example of Paul's contributions to science. More than thirty years ago, he articulated a view of the importance of education and science that we would do well to remember today. "There is hope," he wrote,

> that man can begin to use what he knows to live a better life. . . . If we would but use what we know there would be no need for pollution, pestilence, or poverty. We could control overpopulation and disease; we could eliminate shortage; we could conserve our environment, making it sanative and beautiful. If we lived by the ethics and aesthetics we know, man's inhumanity to man would cease. Our science has made us capable; it could help to make us human. (Brandwein, 1971, pp 48-49)

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Appendix

BIOGRAPHY OF SHEILA K. BENNETT


Sheila K. Bennett

Sheila K. Bennett is professor of Natural Science at the University of Maine at Augusta (UMA), one of seven campuses in the University of Maine System, where she teaches biochemistry, cell biology, human biology, and introduction to the natural sciences. In 1994, she pioneered teaching a lab science at a distance utilizing interactive television and computer conferencing. Today, the course is routinely offered to 100 students each fall semester at receive sites around the state of Maine, allowing them to obtain a degree without travel to a distant campus. Besides teaching at the postsecondary level, she has taught junior high life science and was an environmental educator at the K-6 level. She received a doctorate in biological sciences and a masters degree from the University of Maine and a baccalaureate from the University of Vermont in medical technology. In 1995, she was the recipient of the Libra Professorship and Distinguished Scholar's award from the University of Maine at Augusta, and in 2002, she received a UMA Meritorious Achievement award. She has been recognized by the Maine Chapter of the Sierra Club, the Natural Resources Council of Maine, and RESTORE: The North Woods for leadership in wilderness preservation. She has served as a board member of the Natural Resources Council of Maine, president of the Maine Association of Conservation Commissions, member of the state appointed Advisory Council for the Allagash Wilderness Waterway, and member of the Maine Task Force on Energy and the Maine Coast. Dr. Bennett helped found Citizens to Protect the Allagash and the Maine Appalachian Trail Land Trust. She coauthored a natural history guide to the Allagash Wilderness Waterway.

BIOGRAPHY OF DEAN B. BENNETT


Dean B. Bennett

Dean B. Bennett is professor emeritus at the University of Maine at Farmington where he taught science education, curriculum and instruction, and honors classes on human relationships with nature. He is currently an environmental writer, illustrator, and advocate for wilderness preservation. His published works include many articles and chapters in books, four tradebooks on natural history and wilderness subjects, a teachers guide on environmental evaluation for Unesco, and a children's book in press. His latest book, *The Wilderness from Chamberlain Farm: A Story of Hope for the American Wild*, published by Island Press, received *ForeWord Magazine*'s first place, gold-book-of- the-year award for 2001 books in the environmental category. Dr. Bennett holds a journeyman's certificate in cabinetmaking from the Maine State Apprenticeship Council, a baccalaureate degree in industrial arts education, a masters degree in science education, and a PhD in resource planning and conservation. His long career in education also includes teaching industrial arts, earth science, and environmental education in the public schools; serving as state science and environmental education curriculum specialist for the Maine Department of Education; and directing statewide curriculum projects for Maine in environmental education, state studies, and science and natural history education. He was an invited author and participant in the first, worldwide environmental education conference in Belgrade, Yugoslavia. His awards and honors include the Ford Foundation's Leadership Development Fellowship, the National Wildlife Federation's Fellowship Award in Conservation Education, the Environmental Education Award from the New England Environmental Education Alliance, and awards from the Maine Chapter of the Sierra Club and the Natural Resources Council of Maine for wilderness advocacy. He has served on NSTA's environmental education task force and on the boards of directors of the American Nature Society and the Conservation Education Association.

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