Essays

A Successful Educational Collaboration between Scientists and Educators: *Microscopic Explorations*

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The teacher's guide, *Microscopic Explorations: A GEMS Festival Guide* (Brady and Willard, 1998), is the result of a partnership between Great Explorations in Math and Science (GEMS), a program of the Lawrence Hall of Science (LHS), the public science and curriculum development center of the University of California, Berkeley, and the Microscopy Society of America (MSA). *Microscopic Exploration* supports the MSA's low-cost national outreach program and, also, reaches a very large educational community as part of the GEMS series. Some of the lessons learned through the extremely successful MSA/LHS collaboration are summarized here in hopes that they may be instructive to other scientists and educators as they launch their own partnerships and collaborations.

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INTRODUCTION

Great Explorations in Math and Science (GEMS) is a nationally recognized supplementary enrichment curriculum series of more than 70 inquiry-based teacher's guides and pedagogical handbooks for elementary and middle school that can be aligned with leading standards and benchmarks for educational excellence. GEMS is a program of the Lawrence Hall of Science (LHS), the public science and curriculum development center of the University of California, Berkeley. GEMS is dedicated to developing high-quality inquiry-based materials rich in science and mathematics content, and all units undergo a thorough two-stage regional and national trial-testing process to gather and analyze detailed feedback from teachers and diverse student populations. The program also has the benefit of being part of one of the leading research universities in the world, and many LHS programs, including GEMS, often work in collaboration with leading scientists, mathematicians, and education researchers on the Berkeley campus and/or in the University system. Since GEMS' founding in 1984, more than 1.5 million guides have been distributed. There is a growing national and international network of GEMS sites and centers and there are now more than 2000 active GEMS associates nationwide—educators who have taken

part in intensive GEMS professional development institutes and, in turn, reach many more teachers. Last year alone, more than 21,000 teachers participated in in-service workshops and summer institutes presented by the LHS. LHS curriculum materials are used in over 20% of the nation's schools.

The Microscopy Society of America (MSA) is a vigorous professional society of close to 4000 members, founded more than a half century ago. The membership is an unusual mix of scientists, engineers, and technologists in diverse fields of biological, materials, medical, and physical sciences and technology. Although professional education is an important Society activity, precollege educational outreach is a new initiative, begun in 1994; it has been designated Project MICRO (Microscopy in Curriculum—Research Outreach). A preliminary literature search by the MSA (now available as an expanded bibliography on the Web; see Web Sites Cited) demonstrated the need for an educationally sound teacher's manual to support the MSA's desire to expand and improve the use of the microscope as a tool for inquiry science in the classroom. The MSA is a small society without the staff, budget, and expertise to develop an education program independently. The MSA also realized that independently developed materials, whatever their quality, often are not readily accepted by teachers and school districts, and turned to the LHS for advice. The early decision to collaborate with the LHS has proven to be a very wise one, even though the first contact between MICRO and the LHS was a result of lucky geography rather than

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educational wisdom. The MSA sponsored the development of the guide and collaborated closely throughout the classroom testing, revision, and publication process. Based on LHS advice, middle school was selected as the educational level that would benefit most from the MSA's limited capacity for an outreach effort.

DEVELOPMENT OF THE COLLABORATION

The MSA's initial goal was to support its members as classroom volunteers in an effort to bring microscopy to K–8 schools. The early clarity of MSA goals was very important and helpful—the MSA emphasized that they sought a unit that would convey to students that microscopes are essential and invaluable in a wide spectrum of scientific investigations and can enliven student curiosity and inquiry into many fields of science. They envisioned a unit that, while it might well include the more typical pondwater activities, truly exemplified this multidisciplinary message. The goal was observation and inquiry, not the teaching of “microscopy.”

Caroline Schooley has functioned as the MSA's Project MICRO Coordinator since its inception; she went to the LHS for advice on how to begin an outreach program. At first, both LHS staff and Schooley were unsure about the benefits of collaboration. Schooley discovered immediately that she understood neither current educational concepts nor the jargon used by educators. Fortunately, a 1-week workshop for scientists interested in education, sponsored by the National Sciences Resource Center, was available at that time. The workshop was an invaluable introduction for a noneducator. The understanding of current educational methods gained at that workshop helped Schooley work closely with the guide's senior author, Susan Brady, then of the LHS, to develop the guide prototype. Brady's thesis research had used microscopy extensively, and she had taught children's microscopy classes at the LHS, which made her uniquely qualified to write content for a microscopy-centered guide. The first local MSA-sponsored trial went well; San Francisco-area microscopists helped local teachers try the prototype manual in their classrooms. The prototype was entirely consonant with the GEMS approach, so the GEMS staff—not the MSA—made the decision to include *Microscopic Explorations: A GEMS Festival Guide* (Brady and Willard, 1998) in the GEMS series. This was a fortunate development for the MSA. In addition to curriculum development and publication experience, GEMS staff brought other expertise: a rigorous classroom trial-testing process, familiarity with current pedagogical approaches and national science standards, awareness of the needs and limitations of K–12 schools and classrooms, a network of thousands of dedicated science teachers nationwide, and an earned reputation for quality that facilitates acceptance of new manuals in the GEMS series.

THE PUBLICATION PROCESS

Following the decision to make *Microscopic Explorations* a GEMS guide, other LHS staff became involved with the project. *Microscopic Explorations* coauthor and GEMS Network Director Carolyn Willard, a former teacher with 20 years' of classroom experience, made revisions based on the trial test

feedback and crafted the step-by-step instructions for teachers, students, and volunteers that are such a helpful part of the manual. Lincoln Bergman, GEMS Associate Director and Principal Editor, coordinated the development, refinement, and production process. Michael Isaacson, an MSA Past President and Associate Dean for Research and Graduate Studies of the College of Engineering at Cornell, and Caroline Schooley, who taught electron microscopy at UC Berkeley before her retirement, both contributed special technical sections. Many MSA members contributed the literary quotations used in sidebars, as well as several illustrations. From the start, both institutional partners were willing to learn from one another. That is perhaps the most important lesson of all, and there is no doubt that mutual dedication to shared educational goals is crucial to the success of this kind of collaboration.

GEMS units strongly support the inquiry-driven approach to science, standards, and recommendations advocated in the *National Science Education Standards* (NSES) (National Research Council, 1995), *Benchmarks for Science Literacy* (Project 2061) (American Association for the Advancement of Science [AAAS], 1993), and other leading national and regional guidelines for excellence in science education. GEMS' experience in writing in alignment with national standards produced a guide that can be used to meet a variety of “hands-on science” requirements. The NSES emphasize that inquiry into authentic questions generated from student experiences is the central strategy for teaching science, and that is indeed the main “focus” of the GEMS unit. In addition, the NSES state that students, even at the grade 1–4 level, should have the “fundamental ability to . . . employ simple equipment and tools . . . such as . . . magnifiers . . . and microscopes” (NRC, 1995, p. 122). That may be a “national standard,” but it certainly is not supported in many schools. *Microscopic Explorations* develops that ability, and the learning station format can lead directly to in-depth study of the content introduced at each station; it can be an introduction to more intensive investigations of selected topics.

THE “FESTIVAL” FORMAT

Given the MSA goal of representing the use of microscopes in many fields of scientific endeavor, GEMS also brought some valuable experience in devising activities that utilized a learning station/festival format. In 1990, a research study conducted at the LHS focused on families in a science discovery room using tabletop learning activities. The study suggested that these tabletop exhibits could be excellent classroom learning stations. At the same time, the LHS had been developing large-group outreach programs for schools, some of which were organized as “festivals” with inquiry-based learning stations. Further testing revealed successful classroom teacher and student experience with learning stations. This approach, because it allows students to proceed at their own pace and make their own discoveries, can be a particularly effective mode of presentation for activity-based science and mathematics. As a result, a number of GEMS teacher's guides utilize this approach, such as *Bubble Festival*, *Mystery Festival*, *Build It! Festival*, *Math Around the World*, and *Microscopic Explorations*; information on these titles is available at the GEMS web site.

THE CENTRALITY OF CLASSROOM TRIAL TESTING

The inclusion of *Microscopic Explorations* in the GEMS series initiated a rigorous development process. The GEMS trial-testing process—as well as some preliminary trials that several local MSA societies and educators sponsored, guaranteed educational quality and wide classroom applicability. GEMS units are first pilot tested by the educator-authors at a school near the LHS. GEMS educators and any collaborative partners evaluate the prototype unit from the standpoint of educational effectiveness, need for the content presented, and age appropriateness, as well as alignment with relevant national standards and benchmarks. The initial testing led to the development of a GEMS-designated Phase I (or local) trial version, field tested by at least 24 teachers in the larger Northern California/San Joaquin Valley region. Based on extensive teacher and student feedback, scientific review, and staff and partner observations of local trials, the unit is revised and a Phase II (national) trial version prepared. This is then tested, again by at least 24 teachers, in six geographical regions nationwide. This extensive trial process would be nearly impossible for a scientific society to accomplish and is, therefore, a major collaboration benefit for the MSA, well worth the developmental year that it consumed.

The GEMS testing process ensures several things. The detailed input of teachers and students is central to the development of all activities. All testing includes a wide range of students and teachers, with emphasis on the inclusion of historically underrepresented groups. The numerous revisions and critiques assure that published versions attain a high level of clarity, educational quality, and scientific integrity. Student work derived from the testing process provides evidence of student learning and information helpful in assessing student progress, evaluating educational effectiveness, determining age and developmental appropriateness, and finding out whether the activities are challenging and motivating.

FUNDING

The decision to center the MSA's outreach effort on the production of a good teacher's manual gave the MSA a modest initial cost to fund. Preliminary development was supported by a small amount of National Science Foundation (NSF) funding, but none of the then-available NSF educational programs offered categories adequate for project completion. It took 2 years to assemble grants from multiple sources sufficient to support the development of *Microscopic Explorations*: the Cornell University Materials Science Center, the Glaxo Wellcome Foundation, the Hertz Foundation for the Advancement of Applied Physical Science, and the Hewlett Packard Foundation. No single entity contributed over \$15,000. In each case, an MSA member employed by the source organization helped secure the funding. *Microscopic Explorations* was first published in 1998 and was reprinted with revisions in 1999. Since its initial publication almost 7000 copies have been sold. There has been no need for further funding by the MSA. This is an important point; it means that the MSA has achieved an ongoing outreach that does not require equally ongoing grant support.

IMPLEMENTATION

A strong national GEMS distribution and support system evolved during the years that *Microscopic Explorations* was in development; it has greatly expanded MICRO's influence and effectiveness. The national and international growth of GEMS has taken the MSA's outreach far beyond the scope anticipated for Project MICRO when it began in 1994–1995. *Microscopic Explorations* will continue to be part of an extensively used program indefinitely, without further fiscal support from the MSA. GEMS manuals can be ordered from most booksellers, the National Science Teachers Association, and many scientific supply companies. The bulk of the 7000 copies of *Microscopic Explorations* that have been distributed is in use by teachers who either have attended GEMS workshops or have purchased it independently because they trust the GEMS reputation for quality.

VOLUNTEER PARTICIPATION

A major reason for the selection of the festival format for *Microscopic Explorations* was that its learning station structure is ideal for involving outside volunteers such as scientists who are interested in assisting and/or participating in educational activities. The MSA and its national network of regionally organized scientists stood ready to assist with this, as well as to provide microscopes and other expertise. Scientists invited to the classroom may have a tendency to lecture, to overwhelm with expertise, or generally to have little background in current approaches in science education; the result can be a negative experience for teachers, students, and scientists alike. Several MSA volunteers took part in GEMS associates training and became conversant with inquiry-based science approaches, but the lack of easily accessible training programs for scientists who want to be classroom volunteers continues to be a major problem. Because one MSA/MICRO goal has been to develop a self-sustaining outreach program that does not require ongoing grant support, there is no MICRO program staff available to train classroom volunteers. Although MICRO tries to place microscopist-volunteers in classrooms, most of the teachers who use *Microscopic Explorations* will have little or no interaction with MSA members; realistically, there are not enough members, in enough locations. MICRO reaches some of these teachers with a variety of supplemental information on its web site, including "Ask-A-Microscopist," a question-answering service. The MSA will continue to urge GEMS and other science educators, and other scientific societies, to develop training programs to help scientists prepare for K–12 classroom experience with fewer mistakes and more success.

THE NATIONAL MICRO PROGRAM

Classroom microscopy can be a much more effective and exciting introduction to scientific observation when there is a microscopist-volunteer available in the classroom to support further inquiry and exploration of the microworld. MICRO can supply those volunteers via the MSA's national network of 30 local affiliated societies; 10 of them now have local Project MICRO programs (listed on the MICRO web site), which vary widely in size and scope. One of the largest

programs, in Minneapolis–St. Paul, has a web site (cited below) that provides enrichment for all of the *Microscopic Explorations* activities. Another is a one-microscopist program in the Chicago area; this volunteer distributes sand samples from around the world to teachers who need them to present the “sand” unit of *Microscopic Explorations*. The Cornell program has a staff outreach coordinator who is supported by a research center grant; their program presents annual workshops for Ithaca-area teachers (they have a waiting list of applicants) and Cornell students from several departments are recruited and trained to be classroom volunteers who help the teachers who have attended the workshops.

The New England Society for Microscopy has two programs; one circulates kits of microscopes and *Microscopic Explorations* materials to schools in eastern Massachusetts and Connecticut and another is a microscopist-volunteer program at the University of Vermont. The Vermont MICRO program has been in operation for just 3 years, but it has an impressive record. One faculty member and one staff technologist have volunteered organizational time, and they have recruited an average of 18 University of Vermont volunteers per year to present a total of 20 *Microscopic Explorations* festivals in 16 classes, at three summer science programs, and at a town fair: 437 students, 25 teachers (including many who attended to observe and learn), and 78 other volunteers (parents, etc.) participated (personal communication, Jan Schwarz; jschwarz@zoo.uvm.edu). This is an excellent example of the far-reaching educational effect that the GEMS manual and Project MICRO have created. A full list of MICRO local programs is available at the MICRO web site.

AN ONGOING PARTNERSHIP

One of the most important aspects of the collaboration has been that both partners understand that the partnership needs

to be ongoing. The development, testing, and publication of the teacher’s guide were a central task, but the task did not end there. The partnership between the MSA and GEMS is indeed ongoing—and our collaboration on this essay is just one more example. While some of our experience is specific to *Microscopic Explorations*, it is our hope that some of the larger lessons of our collaboration will be instructive to others and can be applied by scientific societies and educators who aspire to work together.

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