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Online Teacher Education: A Formal-Informal Partnership Between Brooklyn College and the American Museum of Natural History

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This article describes the evolution of a partnership between Brooklyn College (BC) of the City University of New York (CUNY) and the American Museum of Natural History (AMNH) that ultimately resulted in the formal incorporation of the museum's online Seminars on Science (SoS) courses into master's degree programs at Brooklyn College for teachers of science in childhood and middle childhood. The challenges faced and their resolution are described along with program evaluations and participant comments.

Beginning in 2003, a partnership between Brooklyn College of the City University of New York and the American Museum of Natural History sought to mitigate the chronic shortage of qualified science teachers in New York City by providing a mechanism for the AMNH online courses to be given for graduate credit and for teachers to be able to apply those credits towards New York State science teacher certification. By introducing a cadre of local teachers to resources at AMNH using networked learning technologies, the partnership also sought to address New York

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City's lack of resources for teaching science and the need for improved technology skills among science teachers.

Collaboration with higher education partners was an important part of AMNH's original vision, articulated in its 1997 proposal to create Seminars on Science (SoS). The museum set out to design and implement a technology-based model for professional development that makes use of distance-learning technologies to build a thriving learning community for teachers. These courses, which will be described below, were intended to provide teachers with the knowledge and resources necessary to meet the highest national, state and local education standards and to translate them into successful learning experiences in the classroom. The museum sought to address the enhancement of teachers' science content knowledge as well as the opportunities and challenges of providing innovative, accessible, and effective education through online and blended formats and of linking institutions of formal and informal education. Members of the museum's research staff who have an interest in teacher preparation were recruited to serve as SoS course scientists and instructors.

We anticipated that the partnership would provide benefits to both institutions as well as to the student participants. The evolution of the partnership spanned several years and involved collaborators from AMNH, BC, and the City University of New York (CUNY). The challenges faced and their resolution will be described along with program evaluations and participant comments. The work presented here involves the participation of 761 CUNY graduate students (of whom approximately 700 are estimated to be BC students) during the period from 2003 to 2009. Between fall 2008 and fall 2009, 167 BC students participated in 32 sections of as many as six different SoS courses.

OVERVIEW OF PARTNER INSTITUTIONS

Brooklyn College, City University of New York

Brooklyn College is a public, four-year senior college in the CUNY system. It reflects New York City's ethnic richness and wide diversity. Students speak some 95 different languages. Many, if not most, are the first in their families to attend college. The School of Education graduates approximately 500 elementary school teachers each year, most of whom remain to serve the polyglot population of the borough. Approximately 50 graduate students per year earn a master's degree in science teaching. The master's programs in science teaching have attracted an increasing number of candidates for the past several years. The college adopted active learning as a guiding principle for the science education of teachers beginning in 1992 with the institution of inquiry-based science courses for students in education programs. These courses use the constructivist approach to instruction as advocated in *Educating Americans for the 21st Century,* which urged "modeling in

college science and education courses the teaching techniques expected to be used in the precollege classrooms" (The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983, as quoted in the Annual Report of the Brooklyn Plan (Jablon & Cherukupalli, 1993). Since that time, the General Science program has continued to expand course offerings, increasingly incorporating inquiry-based and place-based learning at informal science institutions. In addition to partnering with AMNH, the college has long-term collaborations with the Wildlife Conservation Society, the National Parks of New York Harbor Education Center, and the New York Hall of Science. A new MAT in Earth Science teaching is focused on place-based instruction (Miele and Powell, 2009). The development and continued implementation of these active-learning courses provided the opportunity for the development of a new culture of collaboration between the science and education departments that, while not always smooth, provided groundwork for this inter-institutional collaboration.

American Museum of Natural History

The American Museum of Natural History is a research and educational institution located in New York City. It has a scientific staff of more than 200 who participate in over 100 research expeditions each year and who serve as the stewards of a collection of over 32 million specimens and cultural artifacts. In addition to its own staff, the Education Department draws upon scientists, laboratories, collections, and exhibitions of the museum in providing programs, both online and onsite, for students, teachers, and the general public. AMNH serves hundreds of schools, thousands of teachers, and millions of students with these programs, which include teacher institutes, online resources, student mentoring programs, and much more. The museum has teaching collaborations with many of the major New York City institutions engaged in teacher preparation and education.

Seminars on Science (SoS)

AMNH Seminars on Science (SoS) (Steiner et al., 2003, 2006) serve K-12 teachers across the United States and around the world. The 12 SoS courses offered are helping to address the national need for increased teacher content knowledge in the sciences by connecting teachers across the United States with scientists, master teachers, and educational resources in a networked community of educators. The program is based upon research in teacher professional development (see, e.g., Wiggins and McTighe 2006; Loucks-Horsely et al., 2003) and has served more than 5,000 teachers since its inception in 2000. The courses, each lasting six weeks and typically offered several times each year, have been developed by AMNH scientists, educators, professional developers, and educational technologists through cycles of design, development, field-testing, evaluation, and revision. Courses are

asynchronous and focus on essential questions, key concepts, processes, and tools of current science investigations. Thumbnail descriptions of two SoS courses, *Evolution* and *The Solar System*, are given below in Figure 1. Resources include books on content, CDs with AMNH resources and teaching supports. (For additional information about these resources, see http://learn.amnh.org.) Courses are team-taught by scientists and educators (including, e.g., faculty in the arts and sciences and from schools of education) and offer an excellent model for collaborative instruction.

For each SoS course to be offered for graduate credit by one or more higher education partners, formal course approval from the partner(s) is required. The museum director of online teacher education programs is responsible for SoS

Evolution

The online graduate course *Evolution* draws on the Museum's long-standing leadership in the fields of paleontology, geology, systematic, and molecular biology to involve participants in a modern story of evolution. Participants will learn why evolution is the fundamental concept that underlies all life sciences and how it contributes to advances in medicine, public health, and conservation. The course, which includes original essays and other media, begins with Darwin's groundbreaking work and encompasses the modern use of phylogenetic and molecular techniques to reconstruct evolutionary relationships among all species. In the process, participants use the NIH genetic sequence database GenBank to determine the relatedness of different species. Videos and interactive simulations, including *Meet the Relatives*, compare the features of modern humans with those of both Neanderthals and chimpanzees. Discussions among the instructor, the course scientist, and the participating teachers include the importance of phylogeny, mechanisms of evolution, what defines a species, what makes us human, and modern applications of evolutionary theory.

The Solar System

The Solar System provides an overview of its birth and evolution, its components and their properties, and how these elements interact as a system. Because much of our knowledge remains incomplete, unanswered questions and mysteries figure prominently in the story. The course addresses our scientific understanding of the solar system, how we know what we know, and many hotly debated questions at the cutting edge of scientific research. Media resources and related discussion topics focus on energy generation in stars; formation and evolution of the solar system; planetary surfaces, interiors, and atmospheres; what constitutes a planet; the search for life elsewhere in the Solar System. Participants use GoogleMaps to construct a scale map of the Solar System; create visual graphs comparing planetary features; explore NASA's Astronomy Picture of the Day site; learn about space missions to the Sun, Mercury, Mars, an asteroid, the moons of Jupiter, and Pluto. As with all Seminars on Science (SoS) courses, a summative project synthesizes course material into a unit plan for the classroom.

Figure 1

program development. He had previously helped lead the development of the first Web-based courses at Teachers College, Columbia University. Because of this experience, he was aware of the need to integrate SoS courses with the existing structures and processes of higher education institutions, including course approvals, student information systems, course schedules, instructor payments, student grading, and course evaluations. His familiarity with higher education institutions facilitated collaboration between Seminars on Science (SoS) and its partner faculties and administrations.

The following list of SoS courses suggests the richness and breadth of current offerings, each of which is correlated to the National Science Education Standards as follows.

- Genetics, Genomics, Genethics – Molecular Biology
- The Ocean System – Integrated Science
- In the Field with Spiders – Classification, Anatomy, and Morphology
- Earth: Inside and Out – Dynamic Earth Systems
- Space, Time, and Motion – Physical Science
- The Diversity of Fishes – Classification, Anatomy, and Morphology
- The Link Between Dinosaurs and Birds – Evolution and Classification
- Sharks and Rays – Ecology, Classification and Evolution
- The Solar System – Earth and Space Science
- Water – Environmental Science
- Climate Change – Environmental Science (now nearing completion).

(see Steiner, 2006, for a more comprehensive description of Seminars on Science (SoS)). Seminars on Science (SoS) participants can opt for graduate credits through a national network of eight partnering higher education institutions or for professional development credit through the Challenger Center for Space Education, the International Baccalaureate Organization, and the European Council of International Schools. The courses are recognized by the National Science Teachers Association.

THE PARTNERSHIP BETWEEN THE AMERICAN MUSEUM OF NATURAL HISTORY AND BROOKLYN COLLEGE

Overview and Genesis

Each of the partners in this endeavor is committed to instruction that creates a rich educational experience, engages students in real-world investigation and problem solving, and allows students to "do what scientists do". Both institutions are committed to effective research-based professional development and purposeful innovation as well as to hiring and retaining scientists and educators with content specific pedagogical expertise. Both institutions have demonstrated this through

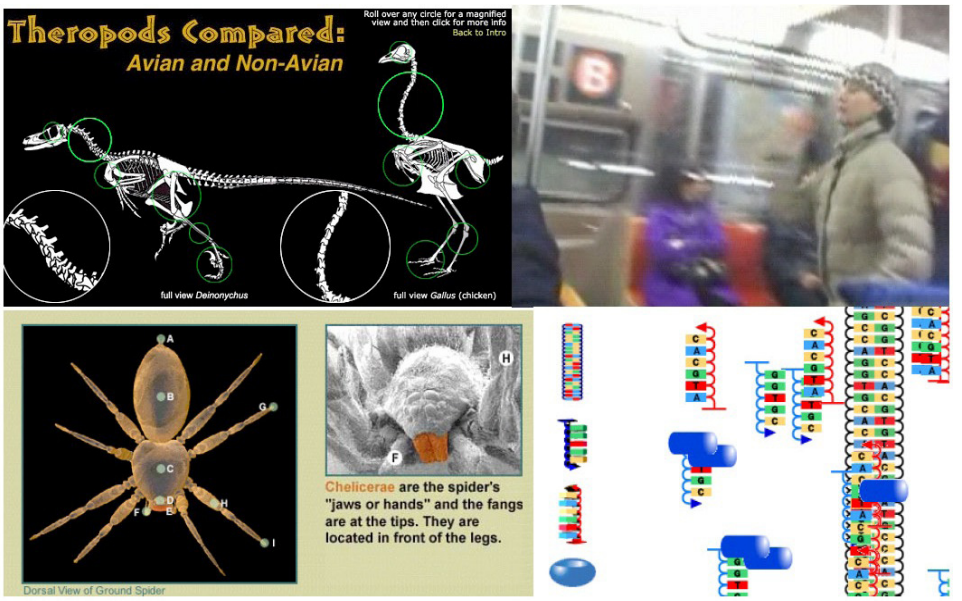

Figure 2. Samples of Seminars on Science (SoS) media resources. Shown, clockwise from upper left: an interactive of a dinosaur and a chicken, including detailed mouse-over comparison of specific anatomical features (*The Link Between Dinosaurs and Birds*); a video in the subway, demonstrating motion in an inertial reference frame (*Space, Time, and Motion*); an interactive of the polymerase chain reaction DNA-replication process (*Genetics, Genomics, Genethics*); a 3D spider manipulative with mouse-over links to scanning electron micrographs (*In the Field with Spiders*).

their sustained commitment both to providing active-learning approaches to science content instruction for teachers and to the vision of science instruction expressed in the *National Science Education Standards* (National Committee on Science Education Standards and Assessment, National Research Council [NRC], 1996; see also Duschl et al., 2007). BC and AMNH have collaborated in the preparation of science teachers since 1999. One of the authors spent extensive time at AMNH as a young informal learner and, upon entering the profession of teacher preparation, sought a connection with the museum. BC's first foray into collaboration with AMNH came after the museum director of professional development invited her to teach a science methods course at AMNH (Dhingra et al., 2006.).

The success of that course led to the development of a new graduate science methods course at BC, *Teaching Science Beyond the Classroom*. Its creation was the first step in formalizing the role of informal science sites in formal teacher preparation at BC. Later offerings of this course incorporated three-day summer science institutes at the museum. As it became clear that professional development institutes for mathematics and science teachers should be sustained (spanning 60 hours or more) and intensive, and place a greater emphasis upon subject-matter content, active learning, and coherence (U.S. Department of Education, 1999),

educators and scientists from AMNH and BC collaborated in the design and implementation of summer institutes that invited teachers to spend two weeks in residence at the museum studying Earth Science (Macdonald et al., 2008). This was followed by a Life Science Institute on Biodiversity and Evolution. These institutes met the academic standards of BC's School of Education and the departments of Geology and/or Biology for courses to be offered for graduate credit that counts toward teacher certification. This collaboration allowed the museum to leverage its substantial human and material capital to contribute directly to teacher certification through a partnership with BC.

Partnership Benefits

The SoS courses, like those at BC, were developed by teams of scientists, K-12 educators and science education specialists who understand the state-mandated science concepts teachers are mandated to teach. This focus on the needs of teachers results in the design of courses that helps teachers learn content using pedagogical approaches that not only reflect best practices in science education (NRC, 1996) but also are aligned with the current realities of New York City classrooms. We knew that many BC students sought the convenience of taking courses online, which allows teachers to manage their time with more autonomy. We also knew that many of them would benefit from learning in an online environment because it would allow them to develop their own technology skills, which in turn would help the students in their classrooms develop those skills as well. However, we knew that a significant investment of time and resources would be required for BC to develop its own online courses. Therefore, faculty at the college were excited about the possibilities of expanding the collaboration with AMNH to include the museum's Seminars on Science (SoS) online course initiative.

The SoS courses have the additional benefit of enrolling participants from around the country (and sometimes even outside the country), thus allowing students to participate in a broader community and benefit from the surroundings, experiences, and perspectives of teachers from many different places. Teachers in all 50 states have participated in Seminars on Science (SoS); in 2009, there were participants from 29 states. This is especially valuable in classes such as *Earth: Inside and Out*, which requires students to map the geology of their local environment. Collaboration with the museum for online courses would provide the college and its students with all these benefits.

The administrative benefits of incorporating SoS courses in the science education program are also substantial. Science faculty at BC who are interested in teaching teachers are often unable to do so due to the demands of their research and the needs of their own departments. Offering SoS courses not only increases the number and diversity of courses available to BC students but also effectively

expands the BC faculty to include all of the SoS course scientists and instructors. This collaboration also allows BC to draw on areas of expertise at the museum that are not represented among the science faculty of the college. Another substantial benefit is that SoS courses can be offered without a full cohort of BC students. For example, BC was able to offer *Space, Time, and Motion* to the small number of its students who needed additional credits in physics to obtain certification in teaching physics. Similarly, the college was able to offer three different biology courses—*Diversity of Fishes*; *Genetics, Geonomics, Genethics* and *Evolution*—to students seeking certification in teaching biology, even though the General Science program offered only one course in life science at the inception of the partnership. This allows the college to more readily tailor programs of study to individual student needs. Thus, offering the online SoS courses makes it possible for the science education graduate program to offer a wider range of courses than would otherwise be possible and to more effectively meet the needs of its students.

At the same time, the museum has benefited greatly from its work with BC. Because CUNY in general—of which BC is a part—is perhaps the primary source of teacher preparation in New York City, its connection with AMNH gives the museum's online professional development resources tremendous credibility in the eyes of New York City teachers. Through this partnership, teachers are exposed at a formative stage to the museum's programs and resources. In addition, the museum benefits enormously from the provision by BC of an ongoing, dependable source of current and future teachers committed to deepening their understanding of science and the process of scientific research. We wish to underscore the central importance of having a faculty champion at BC to recommend consideration of SoS courses to other colleagues at the college, at other CUNY campuses, and at other institutions of higher education.

Because BC students are taking the SoS courses for graduate credit, they are strongly motivated to successfully complete them. These students increase the overall enrollment in SoS courses and, ultimately, enhance the financial sustainability of the program. The BC science education faculty has provided very helpful feedback that has influenced SoS content, online discussions, and teacher activities. One of the authors has secured several grants from the New York State Education Department Title IIBprogram, and this external funding support has made SoS courses available to hundreds of teachers.

Partnership Challenges and Responses

When the SoS courses were under development, those of us at BC could not readily envision a mechanism for administering the courses within the existing structure of

the college. A cost-sharing arrangement that would comply with all regulations governing both institutions had to be created; in the case of BC, these included, in particular, the regulations of the New York State Education Department. The museum needed to cover its program costs and the college needed to establish a mechanism to compensate the museum, rather than individual instructors.

The first steps towards addressing this challenge were taken with the creation of a formal partnership between AMNH and CUNY's then-fledgling School of Professional Studies (SPS) (Picciano and Steiner, 2008). This new arm of CUNY was established specifically to be able to respond to rapidly changing community needs and had, as part of its mission, supporting the development of online courses and professional development offerings at the university. BC shared in the AMNH-CUNY partnership because of its relationship to CUNY, but initially, there was no direct formal partnership specifically between AMNH and the college. The majority of the current enrollment in SoS courses facilitated through this agreement comes through the Graduate Science Education program of the School of Education at BC; two of the authors serve as liaisons in this effort. One of the authors served as liaison to the CUNY School of Professional Studies to promote the partnership with AMNH, and the existing relationship between AMNH and BC contributed to the implementation of that partnership. SPS's charter required that all new courses that SPS offered be recognized by the faculty at one of the CUNY colleges of the university as counting towards a degree program at that college. To obtain that recognition, one of the authors served as the primary ambassador of the SoS courses to the faculty of the science departments and the School of Education at BC.

Evolution of the Partnership

Acting as program head of science education and liaison to AMNH, one of the authors facilitated the enrollment of a small cadre of BC graduate students of science education in early offerings of courses such as *Earth: Inside and Out* and *The Diversity of Fishes*. These students received credit from Adams State College (one of the first higher education institutions to offer graduate credit for SoS), which was then accepted as transfer credit towards their BC degree. Informal feedback from these students was extremely positive and helped to strengthen efforts to create a formal partnership between BC and AMNH. Students appreciated the opportunity to participate in a virtual educational experience "at" AMNH. These early participants recommended the courses to their peers. Informal student feedback also showed that the online courses were rigorous and challenging, helping to dispel the assumption by some faculty that online instruction would not meet the standards of instruction of the natural science departments.

The General Science program of the Brooklyn College School of Education, with the support of the departments of Biology, Geology, and Physics, was poised to recognize the SoS courses as counting towards master's degrees in science teaching. As each SoS course was developed, it was reviewed by the faculty in science education and by faculty in the natural sciences. This review was facilitated by one of the authors, the dean of BC's School of Education, who arranged for a department chairs' retreat at the museum, at which SoS courses were presented. Building trusting relationships across department borders was an essential component in the beginning stages of the approval process. One of the authors, as the program head of General Science, also disseminated SoS course information to the curriculum committees of the natural science departments and met and corresponded individually with faculty to inform them about the SoS course content, rigor, and value for teachers. Members of the campus faculty were invited to review the course content online and, if interested, to become an instructor of record for an SoS course. Involving faculty from the inception was critical for obtaining final approval of recognition of the SoS courses at BC.

As a result of these efforts, the faculty in the natural science departments determined that the SoS courses were acceptable for satisfying science course requirements for graduate programs in Childhood Education and Middle Childhood General Science Education. The Biology Department also allowed *Genetics*, *Genomics*, *Genethics* and *Evolution* to be applied to the Master's Program in Teaching Biology in grades 7–12, and the Geology Department allowed *The Solar System* course to be applied to the MAT in Earth Science in grades 7–12. The School of Education provided each course with a letter of support to present to the SPS board, affirming that the course had been accepted towards its respective master's program. One of the authors also attended meetings of the SPS board to support the SoS courses. Each course was deemed to be equivalent to one of several existing BC general science courses: *Topics in Life Science for Childhood and Middle Childhood Teachers*, *Topics in Earth Science for Childhood and Middle Childhood Teachers*, *Topics in Environmental Science for Childhood and Middle Childhood Teachers*, or *Topics in Physical Science for Childhood and Middle Childhood Teachers*. This allowed students to take SoS courses through CUNY SPS that could be applied towards their BC degree. Students registered through the SoS website.

In the first year, students registered through CUNY SPS and transferred their credits to BC. However, this system proved extremely difficult to administer, and it took several attempts and considerable time to create a simple registration process that would not place significant demands on students, faculty advisors, or the registrar. In addition, because the SoS courses were offered through SPS, they did not appear in the BC schedule of classes. This created another barrier to maximizing

participation in those courses. Ultimately, the decision to adopt each SoS course as an official, distinct BC offering—which was arrived at through a challenging, multiyear process—resolved these problems and is a major element in ensuring sustainability of the BC-AMNH partnership.

The process of adopting the SoS courses began with conversations with each of the natural science departments to ensure their support. Next, both the cooperation of CUNY SPS and presidential-level administrative approval at BC had to be secured so that an agreement between BC, CUNY SPS, and AMNH could be developed. Once this was accomplished, we entered into a pilot year during which SoS courses were listed in the schedule of classes as sections of the designated BC course equivalents, with a note indicating that the sections were special fully online versions of the courses, offered in partnership with AMNH. This gave us a year to complete the formal college course-adoption procedure.

That procedure required that the AMNH course descriptions be translated into the more formal format needed for a college course bulletin. Because the college is committed to a focus on outcomes, it was also necessary to identify the specific learning objectives for each course and to articulate how each met School of Education program goals. The rationale for adopting the SoS courses as new BC courses stated that they "serve a range of department goals for student learning, including science processes, inquiry, using local science resources, understanding the history and nature of science, developing knowledge independently, and the ability to use technology and transmit information" (City University of New York, 2010). Once the new course descriptions were prepared and formally approved by the science education faculty, they were submitted to the Curriculum Committee of the School of Education and from there to the full faculty of the School of Education for approval. It was then necessary to obtain formal written approvals and clearances from all the other departments connected with the SoS courses.

Since many of the SoS courses are interdisciplinary, they required approvals from more than one science department. For example, *The Ocean System* required approval from both the Biology and the Geology departments. Interestingly, *Genetics, Genomics, Genethics* required approval from both the Biology and the Philosophy departments. In addition, all online courses at BC have to be approved from the Department of Computer and Information Sciences. Once all the necessary departmental approvals had been obtained, the proposed courses were reviewed and approved by the college-wide Committee on Graduate Curriculum. The penultimate step was the presentation of the SoS courses at the Faculty Council for a final vote by the college-wide community. Finally, the courses were submitted to the CUNY Chancellor's office. Once the new courses appeared in the Chancellor's Report, they could be officially offered in the schedule of classes. We were fortunate to succeed in completing the process within the year allowed.

The courses listed in Table 1, below, were approved by the faculty in November 2009 and were entered into the BC bulletin and schedule of classes as graduate courses in the Program in General Science of the School of Education.

Table 1

Seminars on Science (SoS) Courses at BC
Earth: Inside and Out
The Ocean System
The Diversity of Fishes
Genetics, Genomics & Genethics
The Link Between Dinosaurs and Birds
Evolution
Space, Time and Motion
The Solar System

SoS Courses as BC Courses

The final approval of the SoS courses had depended upon the sustained attention of a faculty advocate committed to seeing the process through to completion; the collaboration of the science departments; and the full support of the college administration. This accomplishment has resolved many of the most challenging administrative problems that we experienced in the preliminary stages of the partnership. Students no longer need to be individually advised that the courses exist and can be applied to their degree. The courses now appear in the online and hard copy schedule of classes with course descriptions that fully represent their content. Special notes inform students of differences between the college calendar and the SoS calendar. This has greatly facilitated student registration and financial aid processing.

Students can now benefit from the SoS courses without the hurdles that plagued the first SoS participants from our programs. An SoS instructor has been added to the adjunct faculty, providing the SoS courses with direct access to faculty reporting functions such as recording attendance and posting grades. In turn, this allows the college to meet its reporting obligations to the State Education Department. Students no longer need to wait until transfer credits are posted to receive their final grades, which facilitates student advisement and graduation audits; students no longer need special permission to take more than one of several SoS courses—*Genetics, Genomics, Genethics*; *Evolution*; and *The Diversity of Fishes*—which were all originally equivalent to the same *Topics in Life Science* course at the college.

Most importantly, the partnership between AMNH SoS and BC is formally institutionalized with a calendar of systematic interactions to coordinate scheduling

and student data processing between BC and AMNH faculty and staff. Registrars and assistant registrars at each institution know their counterparts and can resolve routine problems without the intervention of faculty advisers. The partnership can now continue to function without the constant oversight and intervention of any one particular individual at either institution.

EVALUATION AND PARTICIPANT FEEDBACK

What Participants Say About SoS

Seminar on Science has been evaluated since its inception by Dr. Mark St. John et al. at Inverness Research Associates, Inc., an independent research organization. The evaluation indicates that SoS courses are effective at providing teachers with authentic science learning experiences. It found that 83% of participants reported that they had gained valuable scientific knowledge with the same percentage reporting an increase in their understanding of how scientists in different disciplines carry out their research. The evaluation further shows that SoS courses not only add to teachers' science content knowledge, but also have direct applications to their classroom teaching. Eighty-three percent of the respondents reported that they had acquired valuable new teaching resources and many indicated that, in various ways, they were incorporating their SoS experiences into their current teaching. Courses strengthened their personal relationship with the discipline, enabling them to bring more to their instructional relationship with their students, including new content (72%), new teaching materials (77%), and new kinds of learning activities that were modeled in the courses (73%). In addition, teachers are using resources derived from the courses to connect their students to the discipline and believe that their students' relationship to science has been strengthened through their participation in the courses (St. John, 2002; Inverness, 2008).

What BC Students Say About SoS Courses

Once the SoS courses were offered directly through the college, it was easy to track student participation through the BC Student Information Management System. Direct registration also allowed the courses to be evaluated as part of the college's regular course evaluation system. Between Fall 2008 and Fall 2009, 167 BC students participated in 32 sections of as many as six different SoS courses. This is roughly equivalent to 10 fully enrolled graduate course sections. Fifty-four percent of those participants submitted the college's standard anonymous online course evaluation. Their comments showed that students in fact experienced many of the benefits that we had anticipated. One class participant commented, "Online courses are great for working adults, particularly if you have family obligations."

The evaluation results indicate that students are very satisfied with the online courses. Of those responding, 83% would recommend the course to a friend. Eighty percent reported that they had gained general knowledge about the subject of the course, and 76% reported that the assignments and projects had been useful. The evaluations are generally comparable to those of General Science face to face courses at BC. Thirty-four students posted comments in response to the question, "What would you like to tell other students about this course?" Of those responding with open-ended comments, 24% used the phrase "great course" or "great class." The same percentage described the course or the topic as "interesting," "eye-opening," or "cool and amazing." Seventeen percent made reference to the online format. One wrote, "It gives the student the flexibility to access it from anywhere at their own convenience," and another commented, "Online courses allow me access no matter where I am. I traveled extensively over the last month and was able to keep up with the work." Two students commented specifically on the resources provided, describing them as "great" and "fascinating." One student had this to say about the online community: "Instructors are always available for help ... excellent fellow students." Another stated, "I enjoyed this class because it was very well organized and all the information that was needed to be found was made easily available."

Although BC student satisfaction with the SoS courses is clearly quite high, enrollment trends indicate that there is a disproportionately high number of students who withdrew from or failed to complete the courses, compared to those in face to face courses. Interviews with students indicate that the time pressure of completing a full three-credit course in a six-week time frame is a significant factor in causing participants to withdraw. This may be especially true for students who are taking the course for credit towards a graduate degree, for whom the course is a high-stakes endeavor. In addition, usually these students are simultaneously taking at least one other course. In comparison, many other SoS course participants are enrolled for professional development credit or personal interest, rather than for credit towards a degree; approximately 68% of Seminars on Science (SoS) participants opt for graduate credit. In the open-ended comments posted in the BC course feedback, 38% of the students described the course as "fast-paced," "time-consuming," or "a lot of work." Seventeen percent also commented that the course was difficult, and over 82% (compared to 66% of all students in General Science courses) considered the course to be challenging or very challenging. One student commented, "I almost wish we were able to spend more time on a few areas." And another posted, "The course was only for six weeks. I wish it was for 12 weeks." We are exploring offering select SoS courses on a twelve-week cycle for cohorts of degree-seeking students at the college, rather than on the standard SoS 6-week cycle.

LESSONS LEARNED

There were considerable growing pains involved in this collaboration. It has taken several years to formally incorporate Seminars on Science (SoS) into the Science Education program at BC. A partnership of this nature requires administrative support—from the dean, the provost, and the president—to create new administrative approaches and structures. In addition, having faculty willing to commit to the collaboration was essential for ensuring its success. Because they are stewards of the academic programming at colleges and universities, their support was absolutely necessary for obtaining formal recognition of the courses. Having a faculty advocate for the collaboration was important, but she could not have succeeded without the support of colleagues, including those in other departments. In particular, the support of the faculty in the natural sciences was essential. It was initially something of a challenge for faculty in these fields, to whom active learning techniques were generally still unfamiliar and suspect, to accept the courses. However, when they were given the opportunity to audit the courses, most of the faculty were won over. An additional challenge to obtaining approval of the new courses was assuring the science departments that they retained the right to decide whether the courses could count towards master's degrees in their disciplines. Currently, three of the SoS courses have been approved for master's programs in teaching science at the secondary level. We anticipate cross-listing these courses with the Biology and Geology departments in the coming year. The rest of the courses are approved only for teachers seeking certification at the childhood or middle childhood level.

It is notable that in 2008, 110 CUNY students participated in SoS courses. In 2009, the total number of CUNY students enrolled in those courses had grown to 305, including 281 BC students. This almost tripling of enrollment occurred shortly after the formalization of the BC-AMNH partnership, which provides a model for deeper integration of the Seminars on Science (SoS) program at other CUNY campuses.

A sustained collaboration between two (or more) major institutions with overlapping but distinct missions and significantly different institutional cultures, hierarchies, calendars, procedures, and accountability is fraught with opportunities for unanticipated difficulties. Once the partnership was agreed upon in principle, implementation presented a whole new set of challenges. It was necessary to learn each others' systems and procedures in order to work together seamlessly. This has required a willingness to listen and to recognize and transcend the differences in culture between the institutions. For instance, the college calendar for course scheduling, student permissions (preregistration clearance), and registration did not coincide with the museum planning calendar and required numerous adjustments by both parties. It was often necessary to compromise on how each institution does things and to recognize what can be negotiated and what cannot. Finding out who does what and informing all necessary parties at each institution was also surprisingly challenging. The successful transition to direct registration required

the creative thinking and willing participation of the college's registrar's office and the ongoing collaboration of the museum registrar. Without openness to new ideas and a wellspring of goodwill on the part of multiple stakeholders at both institutions, this collaboration would not have been successful.

At an operational level, AMNH has worked with BC to begin course sessions on a schedule that, within practical limitations, coincides closely with the beginning of the BC semester. The museum has also worked with the BC Office of the Registrar and regularly assists students in smoothing out occasional challenges with registration. In addition, AMNH coordinates, through the instructor of record, the transmission of the final student grades for each course.

Our common vision—that colleges and museums working together can help to address the chronic shortage of well-qualified science teachers—has influenced the programs at each of our institutions. The realities of accreditation requirements, departmental and institutional course approvals, and other factors have reinforced the museum's commitment to rigorous content, assignments, discussions, and assessments. This commitment to rigor, to model scientific inquiry in the online courses, and to the use of networked learning technologies for purposeful innovation has been influenced by the academic and administrative experience of SoS staff at BC, as well as at other schools of education, including Teachers College, Columbia University, and Bank Street College of Education. The commitment to research-based teacher education, to thoughtful innovation, and to sharing the results of this work with the science education community will continue as we explore extensions of these efforts that may take us more deeply, for example, into mobile devices, social networking, and blends of face to face and online education.

The idea of a museum or other informal science institution offering graduate courses remains somewhat unusual, even a decade after AMNH first started doing so. However, that practice allows participating teachers to experience, often at a formative stage in their careers, the remarkable expertise, resources, and opportunities for student engagement and inspiration offered by the informal sector. Through collaboration, particularly among nonprofit institutions, it is possible to create and offer innovative, rich, dynamic, pedagogically effective online experiences that are sustainable. The museum strives to be attentive to the need within higher education institutions for partnerships that minimize administrative burdens, are financially viable, add value, and maximize the institutions' sense of ownership. It is notable that the BC-AMNH partnership has remained quite stable over time despite widely differing institutional missions, programs, and instructional modalities.

Combining our professional resources in a true collaboration, where the priorities of each partner are fully respected, has helped each institution to expand its horizons and transcend the limits of its world view, meshing the strengths of formal and informal education. The Brooklyn College School of Education and the

AMNH Education Department are proud to have our partnership formalized in the master's programs for teacher preparation.

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