

**RESULTS FROM
THE INDEPENDENT EVALUATION OF
THE SEMINARS ON SCIENCE**

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MARCH 2007
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RESULTS FROM THE INDEPENDENT EVALUATION OF THE SEMINARS ON SCIENCE

Inverness Research Associatesⁱ studied the American Museum of Natural History's Seminars on Science program for eight years, from its inception in 1998 to 2006. We focused on the following research questions:

- ◆ What is the quality and rigor of the science content?
- ◆ What is the nature of the course-taking experience for teachers?
- ◆ To what extent do teachers actually gain access to working scientists and AMNH resources?
- ◆ How well organized and facilitated are the courses?
- ◆ How do the courses benefit teachers as adult learners?
- ◆ How do the courses benefit teachers in their role as educators?
- ◆ To what extent and in what ways can teachers use what they learn in their own teaching?
- ◆ How do teachers believe their students benefit?
- ◆ How do the courses appear to add value to districts' standards-based science initiatives and professional development programs?

We gathered data that represented different views on the courses. To get the perspectives of the teachers taking the courses, we conducted annual surveys and in-depth interviews over 6 years. To gain an independent perspective of the scientific quality and professional value of the courses, we asked experts in the field of science education to critically review the courses and teachers' experiences in them. And to ascertain the relevance and value of the courses as professional development that could support a variety of local science reform initiatives, we asked district science administrators in several different states to conduct critical reviews of the courses.

UNIQUE FEATURES OF SEMINARS ON SCIENCE

We have studied dozens of professional development projects in science over the past twenty years. Seminars on Science stands out as a new kind of professional development resource for science education. First, SOS courses place *AMNH's world-class scientists at the center, sharing their knowledge, questions, and investigations with teachers*. All SOS courses focus on the real ongoing inquiries of museum scientists and their colleagues around the world. The courses put their cutting edge work in the context of key big ideas in science, including biodiversity and evolution, as well as current social and ethical issues. Also, courses make use of *on-line learning technologies to bring the scientific resources of the AMNH to teachers across the nation*. Only a small proportion of the nation's teachers can visit the halls of the AMNH or join an expedition. SOS courses give teachers access to the AMNH in their homes and classrooms, and can involve teachers in nationwide learning communities. Finally, SOS courses aim to *inspire teachers as adult learners of science*. SOS courses mean to give teachers the experience of learning science as the best route to strengthening their teaching of it. SOS courses were carefully designed and pilot-tested with practicing teachers to create a synergy among these distinct features.ⁱⁱ

HOW SOS COURSES AIM TO STRENGTHEN SCIENCE TEACHING

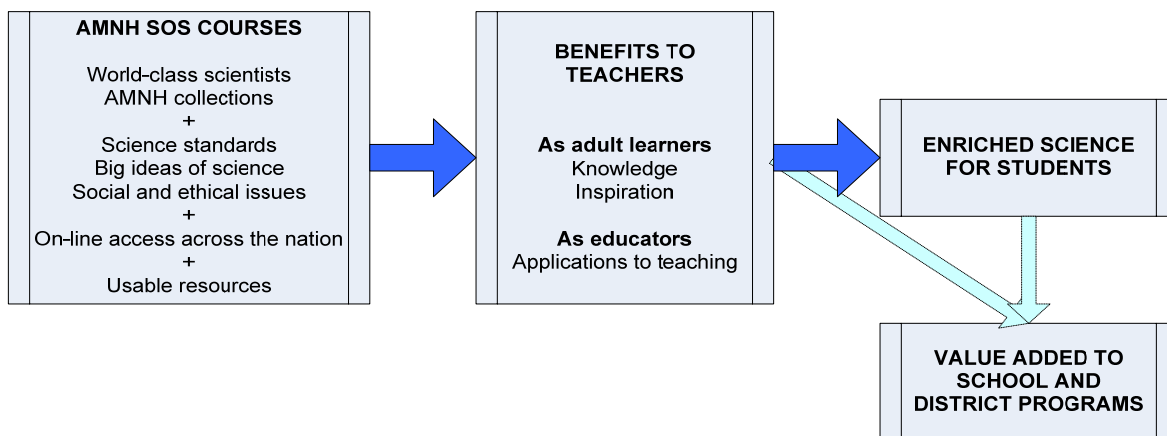
Unlike many courses designed for teachers, SOS courses are not about the teaching of science *per se*. That is, they do not focus on pedagogical theory. Rather, the courses are about science itself – the questions that working scientists ask, the ways they investigate questions, the knowledge that scientists have and that they gain, and the meaning of scientific ideas in society. AMNH courses are designed this way based on a certain set of assumptions, that is, the AMNH’s “theory of action” or logic model about how the SOS courses help strengthen science teaching.

A core assumption is that, as professionals, *teachers are capable of and motivated to continue learning science as adults*, and further, *teachers’ ongoing learning is important to their vitality and skill as teachers of science*. In other words, what teachers learn as adults about the content areas that they teach provides them with benefits in their role as educators.

A second assumption is that *teachers are able to apply what they learn in the courses to their own classroom teaching if their own learning opportunities are well designed and rich*. SOS courses are designed to give teachers hands-on experiences, access to authentic knowledge sources, multi-media materials, and regular opportunities to dialogue with the course scientists and other people taking the course. There is no “one-size-fits-all” way that teachers are supposed to apply what they learn to their teaching; rather, teachers are encouraged to use their new knowledge and the courses’ resources in ways that fit their specific teaching situations.

A third assumption is that when teachers enrich their classroom teaching, their students benefit directly and their schools and districts ultimately benefit, too. That is, SOS courses are intended *to help teachers enrich student learning of science* by adding to teachers’ content knowledge, introducing teachers to cutting edge science, and putting supplemental teaching materials into the hands of teachers. The courses also *add value to schools’ and districts’ efforts to strengthen standards-based science programs* by addressing key science standards, both conceptual standards and standards for scientific inquiry and practices.

This diagram represents the logic behind the design of SOS courses.



KEY EVALUATION RESULTS

AMNH SOS COURSE QUALITY AND VALUE

◆ **The quality and authenticity of the course content**

Teachers of all grade levels find the course content to be rich in foundational ideas of science and also up-to-date. Teachers find themselves excited by the work of the scientists and by the passion the scientists exhibited about their research and the opportunity to share it with teachers. Teachers say they are also impressed with the vast amount of scientific resources available to them. The courses stretch and stimulate them intellectually. Nearly all teachers find the level of science to be rigorous but accessible. For some AP science teachers, the content is familiar. Teachers with minimal science background are nearly always able to get the attention and resources they needed.

[*See the Appendix for quotes from teachers, district administrators, and independent science experts.*](#)

◆ **The overall quality and value of the courses**

The great majority of teachers (80%) say that SOS courses are better than other science professional development that is available to them locally. They cite the quality and amount of science content provided, the care and attention of the instructors, the amount and quality of the usable resources, and the overall level of rigor and engagement. Teachers also appreciate that the courses are available for formal professional development credit.

[*See the Appendix for results and quotes from teachers, a museum educator, and a district administrator*](#)

BENEFITS TO TEACHERS

◆ **Characteristics of course-takers**

As of spring 2006, SOS learners have come from 44 states and Washington DC, as well as Quebec and Singapore. Course-takers are from rural, suburban, and urban areas. Grade level distribution and professional role of survey respondents, 2001-2006:

EL (K-5 teacher)	13%
MS (6-8 teacher)	24%
HS (9-12 teacher)	40%
Others (<i>e.g., college science educators; science museum educators; school librarians and technology educators.</i>)	23%

Middle and high school teachers are more likely to say they have strong science backgrounds, and elementary teachers are more likely to say they have moderate or minimal science backgrounds.

◆ **The experience and benefits of learning online**

Teachers identify many benefits, and practically no downsides, to learning online. Teachers uniformly appreciate the opportunity to get involved in the course on their own schedules; many say they would not be able to take a course any other way right now. For many rural and urban teachers, university face-to-face courses are not readily accessible or convenient. Teachers especially appreciate the opportunity to communicate directly with scientists through on-line postings. They find the course structures and resources very user-friendly and easy to navigate; this is true even for teachers less confident with computers. Some teachers also note how interesting it is to interact with teachers from other parts of the country. Teachers do say that they need access to higher-than-dialup speed and a reasonably recent browser to access most course materials. And a few teachers note that they missed face-to-face contact while learning.

[*See the Appendix for quotes from teachers and district administrators*](#)

◆ **Benefits to teachers as adult learners**

Teachers experience a great many personal benefits from the courses. The great majority say they gain scientific knowledge and understanding of the nature of science that is new to them. Just as importantly, most teachers find that the course rekindles their enthusiasm for and appreciation of science. Further, teachers say the course made them really use and stretch their minds in ways that are all too rare for them, and that this kind of experience motivates and revitalizes them as teachers.

[*See the Appendix for survey results and quotes from teachers and district administrators*](#)

◆ **Benefits to teachers as educators**

The majority of teachers say the courses bring them many benefits in their role as educators. The content knowledge they gain enables them to serve their students better because it is more up-to-date and reflects scientists and their work more vividly and authentically. Also, teachers believe their renewed love of science rubs off on their students. Some say their confidence as science teachers increased. Teachers and administrators alike say the courses provide teachers with a range of new resources they can bring directly to their students.

[*See the Appendix for survey results and quotes from teachers, district administrators, and independent science experts*](#)

◆ **How teachers use what they learn in their classroom teaching**

The great majority of teachers apply what they learn directly to courses they are teaching. They do so in many ways that fit their individual teaching loads and circumstances—from creating new courses, to creating new units, to supplementing existing units with new resources, to bringing tired textbooks to life, to strengthening their explanations of core science concepts. About one out of five of teachers say they are not able to use what they learn directly within the same year in which they take the course because their teaching assignment is not related to the course they chose to take. Also, a small percentage of elementary teachers feel the material is too high level to be adapted directly to their students. However, most of these teachers say the learning experience is still valuable to them personally and professionally.

[See the Appendix for survey results and for teachers' accounts of how they have used what they gained from the Seminars on Science in their classrooms.](#)

ENRICHED SCIENCE FOR STUDENTS

◆ **Teachers' views of the benefits for their students**

Slightly more than half the teachers report that they can observe benefits to their students within the school year after they take the SOS course and begin applying it to their classrooms. They say their students become more attuned to the natural world and respectful of its diverse forms of life, make better connections between current events and science, become motivated to pursue study of scientific phenomena on their own, and increase their understanding of important scientific ideas. Some teachers note that their students begin to see themselves as scientists. Also, some teachers report that students develop a more realistic understanding of the nature of scientists' work.

[See the Appendix for survey results and quotes from teachers](#)

VALUE ADDED TO SCHOOL AND DISTRICT PROGRAMS

◆ **Relevance to science standards, assessments, and teacher qualifications**

Teachers and administrators alike agree that the SOS courses address many of their state and local science standards—both content standards in several areas and standards for inquiry and investigative processes. Some teachers have observed that course content includes topics that appear on student science assessments. Some district administrators say that SOS courses can address teacher quality issues by bolstering the science backgrounds of teachers teaching out of field.

[See the Appendix for quotes from teachers and district administrators](#)

◆ **How SOS courses add value to district science improvement efforts**

Science reform leaders' views about the potential of SOS courses to add value to their district professional development programs depend on how much they know about the SOS courses.

When they know very little about the SOS courses, district science administrators are concerned that taking the courses might derail teachers from district standards and curriculum or promote individualistic teaching approaches. They base this concern on the belief that teachers' professional development has to be specific to the local adopted curriculum – especially for elementary and middle school teachers. They also are not certain that the courses address science standards.

However, when district science leaders learn more about the quality and richness of the SOS courses, they realize the courses can contribute to teacher learning in ways that district professional development cannot do. District programs cannot offer a comparable degree of depth of content, nor can they connect teachers to real working scientists and the vast resources of a world-class science institution. Ultimately, science administrators see the courses as adding value to local efforts by complementing professional development offerings and giving teachers supplemental curriculum resources.

[See the Appendix for quotes by an elementary teacher and district science administrators](#)

◆ **Recommending SOS courses as a good investment in teacher professional development**

About two-thirds of teachers say they have recommended SOS courses to their colleagues. As part of their recommendation, they want their colleagues to know that the courses are more challenging than most professional development offerings and will require a few hours a week and willingness to do the assigned work. They assure their colleagues, though, that the investment will pay off because of the quality of the course, the excitement of the learning experience, and the lasting value of the resources.

District administrators, too, recommend the courses as valuable professional opportunities for teachers. Similarly, independent science experts recommend the courses because of the degree of quality and engagement; one noted that the courses may also be accessible to advanced high school students.

Teachers and administrators alike say the price and 3 units of graduate credit are appropriate for the course.

[See the Appendix for quotes by teachers, district administrators and an independent science expert.](#)

ⁱ Inverness Research Associates is an independent education evaluation group headquartered in Inverness, California. We study investments in educational improvement. Visit www.inverness-research.org.

ⁱⁱ See the full-length report on the Inverness Research website: http://www.inverness-research.org/reports/ab2002-10_%20Rpt_AMNH-SOS_LessLrnedPh1.htm

APPENDIX

QUOTATIONS AND SURVEY RESULTS RELATED TO EVALUATION FINDINGS

◆ The quality and authenticity of the course content

Elementary teacher-

The information was up to date, very relevant to current topics in biology. The hands-on approach that went along with it was the same caliber that you would get at a college.

Middle school teacher-

I have a science background and the people running the course had a much deeper science background than I did. Unusual for teacher pd – a really high level science course. There was a lot of info that was over my head and I thought it was really good because of that.

High school teacher-

The readings, questions, activities took me to another dimension of thinking.

District science administrators-

It is very sophisticated, amazing. The scientists involved are extraordinary, and they are from all over the world. It is incredibly rich.

I really think they are content courses that don't just present new and interesting information about what is going on in the field, but really engage the teachers deeply through an interesting approach to inquiry in this online work.

This is cool stuff!

Independent science experts-

The topics and representation of the material lent themselves well to good discussions about the nature and politics of science. How did we get into these ethical dilemmas in the first place? Is there something about the practice of science in our times (and ancient) that leads us to these questions? Week 1 in particular raised questions about the nature of science that the students really grappled with. Consider Mendel and his "discoveries" – is it possible, given the nature of his work, that he "fudged" his data to reflect his predictions? And, why were his results ignored for so long? Was there something about the socio-cultural context that prevented his findings from influencing biological thought? Would the realization that he did manipulate his data make his contribution any less significant? The students often raised the question: "Why has it turned out this way?" The guides were good at encouraging this.

The fundamental ideas of physical science- motion, time, space, matter and energy- were considered from the standpoint of their inherent characteristics, the historical development of the understanding of these ideas, and the impact of this understanding on technological development. The complex and puzzling relationships among them were explored. In general, the scientists' weekly lectures were written with great clarity. Skillful weaving of descriptions and analogies into the discussion make the content accessible even to someone with limited prior knowledge of the topic. In particular, the text of the chapter on Energy was beautifully crafted. The author took the reader on a seamless trajectory, from familiar ideas to the edge of the human understanding of the interaction of matter and energy. And throughout, insights into Dr. Einstein's questions, thinking, and deductions anchored the discussion. ISE

In my view, this course is not about the methodology of teaching physical science. It is about letting your mind soar. It is about tantalizing images that dance half naked in your head, just slightly beyond your comprehension. You can't quite wrap your mind around them, but they won't go away and leave you alone.

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◆ **The overall quality and value of the courses**

80% of teachers say that SOS courses are *better* or *much better* than typical professional development course available locally.

73% of teachers say SOS was a source of course credit that is *useful* or *very useful* to them professionally

Elementary teachers-

There's a lot of content knowledge. It's not wasted time. A lot of it was interesting. You could ask questions and learn a lot in the discussion groups, reading what others had to say about it.

The expertise of the guides through the class. Their work and knowledge and willingness to share with their students. The step by step process that they led me through was awesome. They had the patience of saints and gave forth the confidence in the work that I had to accomplish. I felt their continued support. They gave individualized attention to each and every student, something that is not done in a lecture hall. They made me get out in the field and learn. They gave me the confidence to go and teach my students the further knowledge that I gained.

Middle school teachers-

All of the SOS courses that I have taken have maintained high standards for quality of content, presentation, and interaction. The resources are extensive, current and relevant. There has not been a single course that I've taken that has not had a direct and positive impact on my science curriculum. There is simply no comparison to other distance-learning courses.

It is by far the best online course I have taken as far as resources and the overall web design of the course. It also I think had higher level content than most science professional development I have seen available to middle school teachers, even at museums. I can't say enough about how good their web site was; the ones in our district are very plain – this had so much stuff on it, as far as images and video clips. It was really great.

I feel that professional development courses I've taken in past have not lived up to what I was hoping to get out of them. This one, I know I've benefited from it. If professional development is a way to challenge teachers to learn more, it meets and goes beyond other courses I've taken.

High school teachers-

It has been a benchmark for me – if I ever investigate other online courses, it will be held to this standard, a very high standard. Very professional, very knowledgeable, very user friendly, very interactive.

A lot of the PD available to us is more centered on the educational field as a whole whether it be on learning disabilities, or awareness of sexual preference. But these focus on the science. You want to provide your students with the most current up to date science content possible.

Museum Educator-

If I had to choose between going to some of the professional development I've gone to and taking another SOS course, I'd take an SOS course. I learned a lot more than in other courses and learned it so I could teach it. It made it more applicable.

District science administrator-

AMNH has great people and great stuff. Museums are best suited for this – a wealth of resources.

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◆ **The experience and benefits of learning online**

Elementary teachers-

I was not very computer literate, but everything was very easy for me to find, and navigate.

It was self-explanatory. You had links that took you everywhere you needed to go to. If you had a problem you could email and they would get back to you quickly with everything that you needed.

Middle school teacher-

I have taken a number of grad courses and I really like these. They go with my lifestyle – online, get a week to post answers. I have two small kids and am a single mom. A lot of work but I could manage it within my own time frame and that was important to me.

High school teachers-

The web sites were extremely clear. I saved a lot of the links to use with the students sometimes. And it was picture friendly too – it wasn't all words.

A chance to continue to learn in a structured way out here in a rural area in a poor state.

District science administrators-

On-line facilitation is skilled, careful, caring.

Online mode means they can participate when they have the idea in the middle of the night, not restricted to questions during class.

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◆ **Benefits to teachers as adult learners**

Teacher survey results-

Benefits to teachers	% agree or strongly agree
Added to my personal background knowledge of science	83%
Rekindled my passion for science and the work of scientists	67%
Gave me deeper insight into the work of scientists	64%
Provided a bank of resources I can draw upon for my own learning	77%
Motivated me to continue to learn more about the course topics on my own	67%
Motivated me to take more science courses	61%
Increased my familiarity with/appreciation of AMNH resources	80%

Elementary teachers-

The Link Between Dinosaurs and Birds course has helped my understanding of evolution so much! It introduced me to cladograms and the scientific approach taken by paleontologists. The textbook and essays were fascinating - all was new to me. Feathered dinosaurs continue to be discovered. New discoveries in the field continue to increase our knowledge of dinosaur and bird natural history.

I liked how the material was cutting edge and that scientists were involved in the course content and in course discussions. I also like the fact that evolution was stressed as was inquiry.

Middle school teachers-

I was extremely impressed. I was able to finish each of those courses and feel as if I really took something from them. Whether it was essays I'll use with my students, interactives I can show them, or furthering my own professional knowledge, I really felt I came away with something valuable.

The interaction with the course scientists and other students around the country was most valuable. For the first time in a long time I felt challenged and pushed to my limits.

High school teachers-

In terms of an adult learner, science is a field that always changes. Nothing except the laws stays the same and even those things can be challenged.

The general questions they asked were very tough, thought –provoking questions – not regurgitate the facts kinds of things. Made me think and think.

The scientist was so very positive in what she did, even when you were off mark. As adults, we don't want to make mistakes and in each course there was something I just didn't understand. When I reached out for help, it was there in a positive way.

This was rigorous learning in an area that I had little previous knowledge. It was professionally and personally extremely valuable and while it was hard work it was fun too.

District science administrators-

Very powerful use of specific scientific work and topics to produce understanding science, e.g., fishes and evolution.

Courses help teachers see iterative detective work of science in action.

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- **Benefits to teachers as educators**

Teacher survey results-

Benefits to teachers	% agree or strongly agree
Enhanced my content knowledge in a subject area I teach regularly	61%
Helped me to learn a new content area that I may teach in the future	60%
Provided a bank of resources that I can share with my students	68%
Introduced me to new kinds of materials and media I can use in science (e.g. simulations, websites)	67%
Provided me with hands-on, inquiry learning experiences that can serve as a good model for the kind of work I can have students do	55%

Elementary teachers-

The information is so up to date and relevant to present ecological conditions, you can relay current information to the students.

It reminded me of how much I liked science when I was in grade school. I want to instill a love of science in my students.

Middle school teachers-

The directed learning was very helpful to me. The topic, dinosaurs, is of high interest to students and my background is weak.

Communication with the AMNH scientists and other educators. As a teacher in a very small school, I am the entire science department. I can talk to other teachers, but not other teachers about science curriculum. The course gave me the opportunity to interface with others teaching the same course as me. As such, I was able to gain insight into the approaches used by others.

A lot of the student projects we have done in class I might not have done without this course. I know they benefited from me being exposed to this kind of work and new information. The lessons are now more specifically tied to modern research.

I am a better teacher simply because I gained content knowledge and that benefits my students.

High school teachers-

I loved being able to learn about the latest scientific discoveries and ideas. It is so important for those of us who teach science stay on the cutting edge of what is going on in our subject.

I can't say that I went out and taught specific things from the course, because I am teaching at such a basic level, but it is all part of being comfortable with the subject matter, and it is difficult to get earth science courses if you are not in college.

It was at a level of science that pushed the envelope for many people that weren't marine biologists or geneticists to expand their vocabulary and knowledge – but not so far over our heads that we never knew what was going on. We did take it directly back to our kids. And we had projects at the end of each course that had to directly relate to our classrooms.

District science administrators-

The forum has evidence that teachers have deep conversations about science and also about bringing the resources to their own students.

Gives them high quality resources (readings but also others, like videos, photos, interactives) to give their students.

I think the course gets them engaged in the discourse and nature and relevance of science, in a real immediate and personal way and it gives them a lot of resources and examples and stories and models to use in their instruction.

Gives teachers with no contact with scientists a real opportunity.

Independent science experts-

For at least one assignment [in Genetics], the participants were asked to consult a website that contained a database of genetic information. This use of "authentic" scientific data is a great opportunity for teachers, especially if the data contain information that is personally interesting or useful. In this case, the teachers were intrigued by the site and wanted to create a way for their students to access the information. This example illustrates the notion that as more and more scientific data appear on the internet, more opportunities for students and teachers to get a sense of "real" science become available. Courses such as this one are ideal for helping teachers find, work with, and think about ways to engage their students.

The topics prompted students to think about their current ways of teaching genetics in the classroom, and provided them with ideas for exploring ways to encourage their students to think more deeply and personally about science.

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◆ **How teachers use what they learn in their classroom teaching**

How teachers use what they learn for their teaching	% reporting yes
I used what I learned to create a unit for my students	78%
I made some of the resources available to my students	60%
I shared the materials and resources with colleagues	52%

Elementary teachers-

Have integrated the ocean system into my units on the carbon cycle, local weather and global warming.

I teach a unit on habitats...this course has helped me expand the Ocean part of that unit a lot. I have to use a lot of my own materials since our science books are from the 1980s and we don't have enough for each student. Since I use supplementary materials, this has provided me with even more ideas and materials to use.

Middle school teachers-

I am in the process of designing and teaching a new physical science course that includes earth science concepts. I was able to substantially increase my background knowledge about the internal workings of the earth. This has allowed me to see the connections between physical science concepts (such as density and heat transfer) and earth science processes like plate tectonics. The units I'm writing for my students benefit from this integration and by having a real-world context to relate physical properties to.

I was able to use 75% of the stuff. Obviously there will be things you aren't able to use. It made me aware of resources I didn't know existed.

Presently I'm in the process of teaching my biodiversity unit. I've used the texts that I bought along with the class to highlight some native spider species. It has also allowed me to field questions about poisonous spider species. I'm planning on using some of the field techniques that we discovered during the course to find organisms when the students take to the outdoors. I will also use some of the websites to potentially identify a species.

when I took the spiders course, we read an essay – Blair – one of first scientists to allow himself to be bit by a black widow. He was taking notes as a scientist while he was going through this. 8th graders loved this. There was really good science in there as well. We talked a lot about venom and how that affects our bodies – spiders versus snakes versus different types of toxins.

All the lessons I used with my class through the SOS course added greatly to the geology unit I taught this past year. My assignment to observe and investigate a local geographic feature translated beautifully into a project for my students.

High school teachers-

I have used most of the resources from the SOS courses in both my vertebrate zoology and human anatomy&physiology classes. I have also used both of my final projects in part or in entirety during the last marking period of this school year.

I designed an entire unit around the information that I gained from taking Genetice, Genomics, Genethics, and presented this unit to my 10th grade Biology class. They seemed to get a lot out of it at the time. However, the thing that made me really proud was when the state testing came around a few months later. One of the essay questions involved genetically modified foods. My students came to class that day telling me that they ran out of time before they ran out of things to say about it! They were so proud of themselves - it made my day.

I am currently teaching paleontology. I have been able to share the CD I received with my students and have used info from the web sites used during the course. I have also used the essays as readings for my students. The lesson plans I developed are being used this semester.

I was able to explain current theories about evolution with more authority.

The structure of the course enabled me to take the curriculum as far as I wanted to go. If I really wanted to dig into a topic (pun intended...) I could. One night I was up until 3:30am because I got so excited about what we were studying, I couldn't stop reading about it and looking for more information. The kids ended up doing similar things in class. I believe it was in large part because MY excitement showed and it was catching!

I absolutely am able to use some of the genetics in my classroom. Not just lectures but also some of the discussions that others brought in. For example, I do discussions and debates with my students on ethical issues. One example was talking about the human genome project and designer babies. Is it ethical or moral for people to decide what their child should be? One of the learners in the course, during the online discussion, brought up potential effects of losing genetic variety. I hadn't thought of that.

Museum educator-

I took the information from the course on "Sharks & Rays" and created a resource notebook. Here at our museum we teach lessons in our Estuary exhibit area wherein we do have a resident skate. I can now expand the knowledge I impart during lessons regarding both it and its shark relatives. We teach one very specific lesson using aquatic creatures, studying their use of hydrodynamics as inspiration for students to understand and inspire them to create something with aerodynamic design. Having learned much of how sharks and rays are designed to move in nature, these concepts were imparted into our student tutorials. Shark movement is inspirational to understand the racecar moves on a track, a plane flies, and a submarine dives. It made our course more inspiring with scientific principles applied more eloquently.

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◆ **Teachers' views of the benefits for their students**

Teacher survey results-

Benefits to students in my classroom	% agree or strongly agree
Helped students connect science in school to the real world	60%
Made the work of scientists more understandable to students	52%
Increased students' understanding of scientific inquiry	50%
Increased students' access to and knowledge of latest research	55%

Elementary teachers-

They notice the behaviors of the fish in the school tanks and how different they react in certain situations.

The students were really excited to bring different kinds of rocks and stones to school to sort and classify. They even started getting books about rocks and mountains from school library when before, they seemed more interested in fiction.

My students gained a better understanding of how the outside world connects to what we are learning in class.

Students show an increased ability to understand evolution by being able to compare and contrast the anatomy of organisms, by using examples of how traits can be successful adaptations to an environment. They see how the fossil record occurs over time (long periods of time). They seem very interested in current fossil finds.

The students felt like scientists themselves when they brought in the spiders for others to observe.

Students have more respect for living things - they don't automatically kill spiders when they see them.

Middle school teachers-

Real student projects spinning off from the earth course are taking the place of book instruction and have been better rec'd by students.

Shortly after the completion of our genetically modified rice project, i saw an article in the newspaper concerning the Angolan government's decision to deny entrance of genetically modified foods, regardless of the starvation going on in that country. Students read the article

and we discussed the reality of GM foods being a contentious issue, one where both sides have valid arguments.

Students became more independent in researching and investigating answers to their own questions.

The students had the chance to learn about the reality of dinosaurs and not just what "Hollywood" has been telling them. They were also able to see the real work of scientists and how it is far from an easy job. Finally, they had to cooperate as a team to share the work and complete this unit.

High school teachers-

Students look at research and working in a museum as boring. For them to see the dynamics of the researcher's work and then how to make it interesting to people who go to a museum, opened their eyes in a different way to what scientists can do.

I think the students really enjoyed learning about ethical issues in genetics and biotechnology. They are able to see how this applies to the real world and potential issues they may face in the future.

Students were bringing in newspaper articles on the topics, bringing up what they had heard about in other media. The topic was very motivating to two students who were underachievers before. (Both became "experts" in the molecular clock!)

None of my students had ever really taken a close up look at spiders before. Now they tell me that when they spot them, they purposely walk up and observe instead of just allowing them to blend into the scenery.

Residing in a rural area, students often lack exposure to scientists and potential career paths. The AMNH courses are a way for students to connect to these scientists and promote their curiosity.

Increased students understanding of ethical decision making and increased their self esteem as they became "experts" answering questions on GM food.

When the students realized I was communicating with real scientists it made them view science as something more than just facts out of a textbook. They appreciate the discoveries people have made and how important they are to the whole world.

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◆ **Relevance to science standards, assessments, and teacher qualifications**

Elementary teachers-

As I was working on my final project and pulling together the curriculum frameworks that I was addressing, I realized that I was going to be using standards from life science, science and technology, physical science, earth science and especially unifying themes and concepts and science as inquiry. I've learned over the past few weeks that science may be solitary, but is never done alone. I've remembered that each new discovery opens the way for further investigations and I've learned that each system is interconnected to every other system. I think I was most struck by this when I learned that phytoplankton can affect the weather. I think that the more we specialize, the more we can generalize but isn't it good that we have some "big picture" scientists that can put it all together.

In Texas we have a specific essential knowledge and skills text – comparing today's animals to animals in the past. It's very applicable to what I taught then and am teaching now.

Middle school teacher-

Students used information from a unit I designed, based on a course I took, to enhance their performance on the New Hampshire state test. And they felt good about their ability to do so!

High school teacher-

We at Sampson County are looking at AMNH as a source for other teachers getting certified in science.

District science administrators-

These would be relevant to NCLB "teacher quality" mandates for teachers who need grad credit in science topics.

Has real potential for science-oriented teachers but who are teaching out of subject.

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◆ **How SOS courses add value to district science improvement efforts**

Elementary teacher-

This gave me some new ideas to use with the Mammals (First Hand Learning) kit. Can use it with the Life Structures kit.

District science administrators-

It can complement the work of a district trying to implement a science curriculum. I would want my biology teachers to take both genetics and fish. These courses go in depth and are very high quality, more than we can offer as a district. We need resources like this. I can work with teachers on integrating it into our curriculum.

The lesson plan that I saw [created by a teacher as a final project] was designing an enhancement to their existing curriculum, so that implies they would stick to the curriculum, but they would enrich it with these connections.

These courses serve a useful function – to support and stimulate teachers who like science and seek pd. They will figure out how to bring it into their classrooms – that type of teacher gets excited, knows how to get kids excited. If they are in a healthy school, they can get other teachers excited – it becomes contagious.

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◆ **Recommending SOS courses as a good investment in teacher professional development**

Elementary science teacher-

I think they would enjoy it. It's not an easy class. They'll have to read and do research. It's not something you can just sit down and do. But it's rewarding and very interesting.

High school teachers-

I would say that especially as someone who was leery of technology and e-mails – the whole system is so easy that even if you are a technophobe, you really don't have to worry about it. If you are taking it for graduate credit you have to expect to do a lot of writing and at a certain level. There will be all different kinds of reading – from texts, scientists' articles, etc. So, people have to realize that it is going to be rigorous, and that is what it should be.

My advice would be that it's worth the investment. A lot of people I know are hesitant to get back into studying but it's really nice because the online course gives you the ease of working anytime you want. I would be able to express my thought late at night. Take the course and enjoy it. There's a lot of information that's out there and the professors and guides are very knowledgeable and helpful in guiding toward the right information and right thought process.

District science administrators-

The courses seem feasible and accessible for teachers if they know up front that it is a real, substantive grad-level course.

The price seems right compared to university 3-credit grad-level courses.

Independent science expert-

I would certainly recommend this course to any science teacher because it is a lively and engaging review of the way scientists have thought and are thinking about the big ideas of time, space matter and energy. I also think it has possibilities as a course for very bright high school students who are eager to grapple with challenging ideas and whose needs are poorly met by the standard high school physical science curriculum.

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