FROM THE ARCHIVES: DISTINGUISHED TEACHING SCHOLAR INTERVIEWS

There is much evidence, from data and stories from the field, about how particular learning environments matter—a concept of environments that goes beyond the physical to embrace also intellectual and social environments.

In FROM THE ARCHIVES, we feature a collection of reflections by STEM faculty honored almost two decades ago as *recipients of the NSF Director's Award for Distinguished Teaching Scholars*.

> *These scholars have a special distinction in that they influence entire academic cultures. They make students major participants in the process of discovery. They also promote activities that expand the education process beyond the boundaries of the university into local schools and communities. They are true leaders in both the scientific and academic realms. Their pioneering research, already well recognized, is equaled, and sometime surpassed, by a rare talent and commitment to communicate and teach knowledge.*
> — Arden L. Bement, Jr. Acting Director—National Science Foundation.

These reflections are prompted by the question[1] *if a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?*

The value today of these stories from the field is on several levels. They are an a historical record of early generations of pioneering STEM teaching scholars whose work is now reflected in thousands of classrooms and labs across the country. Stories such as these, then and now, are a reminder—a cautionary reminder—that attention to the intellectual and social environment for learning must be given before, during, and after attention to the physical environment for learning.

On another level, these stories are a resource for the emerging LSC Assessment Initiative. Collectively, they speak of what works in engaging students, in influencing the academic culture on a campus and beyond. The early stages of this initiative will be to document what we know and what is the evidence for what we know.

[1] Posed in an interview by Jeanne L. Narum, Director of Project Kaleidoscope (PKAL) (1989 – 2010)

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

TANYA ATWATER

PROFESSOR OF TECTONICS DEPARTMENT OF GEOLOGICAL SCIENCE
UNIVERSITY OF CALIFORNIA, SANTA BARBARA
2002 DTS AWARD

In lower division lectures I present and explore the most beautiful examples I can find for each phenomenon—giant crystals, beautiful slide images, the most pleasing map presentations, the most vivid visualizations I can muster. Of course, I also insist that they read and learn the basic material and I keep a running feedback going to reinforce this: "question of the day" each lecture, term papers, lab reports, tests. I also believe in the crucial importance of personal, "hands on" experience and have revamped the labs to be more fun and to include more field experience.

My goal with our non-major students is to instill life-long curiosity and interest and caring for the earth. I hope to get them to choose to read geological articles in the paper, to choose nature programs over a sit coms, to view earth problems as problems that are interesting and vital, that deserve their attention.

In upper division and graduate classes, I am primarily trying to help the students prepare for their professional lives. I still include my passion (can't help it) but it is only a reinforcement of a passion most of them have already. My specialty, plate tectonics, is an excellent vehicle for bringing together disparate information from their other geo-classes and for constructing a broader mental order—a world image. I also include many activities in these classes that develop important skills: map interpretation, literature searching, paper writing and critiquing, cooperative learning, oral presentation. I want them to come to view earth problems as problems that are interesting and vital, that deserve their attention.

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THOMAS BANCHOFF

PROFESSOR OF MATHEMATICS
BROWN UNIVERSITY
2004 DTS AWARD

Student responses seem to drive the entire enterprise, either comments made in class to my semi-rhetorical questions, or suggestions that come from their submissions to homework and reading assignments. Often those responses appear on the computer screen attached to my laptop, along with interactive demonstrations prepared by students working with me over the summer, often modified by students working individually or together on projects arising from conjectures in class or online.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

The new conjectures that we will examine before the next class meeting arise from the class interaction and show up within one day as formal assignments or discussion questions, both of which receive online responses. The visitor receives the impression that she or he has seen a process, possibly that she or he has been part of it.

[Connections that have been important to me]: From the time of my arrival at Brown University, I have collaborated with computer scientists as well as colleagues in many other disciplines. I have always received encouragement from the Brown administration, and from the National Science Foundation.

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PAUL BIERMAN

PROFESSOR OF BIOLOGY
UNIVERSITY OF VERMONT
2005 DTS AWARD

Energy, fun and hard work! It is my love of science and fascination with the Earth that drives me to do what I do every day and that's what I try to convey to my students at all sort of levels. Sure science and learning are hard work but isn't everything that's worthwhile? In my classroom, there's lots of talking and moving around, even when I am teaching 230 students in an introduction to Earth Hazards class. The TAs and walk the aisles. We ask for students to shout questions out to the group.

We try our hardest to get people to think, to speak to each other, to question what they think they know. We get people down front doing silly things like using giant slingshots to impale birthday cakes with apples—the best we can do to simulate asteroids striking Earth. The analogy's not perfect but I can tell you they never forget the demonstration and they walk away laughing, knowing that things fall from the sky, and realizing that their professor is a person who likes to have fun too. My former chair used to remark that I taught 200 students like I was teaching 20. He was right on target.

Spending time with my graduate students is not the same, of course, as hundreds of undergraduates, but the same ethic of working hard and having fun prevail. My students and I work in the field all over North America and indeed all over the world collecting samples; one of the best parts of being a geologist is the time we all get to spend in wonderful places.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

ROBERT L. DEVANEY

PROFESSOR OF MATHEMATICS
BOSTON UNIVERSITY
2002 DTS AWARD

A visitor to the mathematics courses I now teach would probably marvel at how different these courses are from the way they were in ancient times (pre-1985). Now, with the computer at my side, I can have my sophomore level students tackle the kind of real-world differential equations that were impossible to solve in the old way-when all we had were very specialized analytic tricks and the only differential equations of interest were usually linear.

Now I can give my students a glimpse of what is new and exciting in mathematics, instead of confining my attention to seventeenth century ideas from calculus. Finally I can introduce very simple-sounding questions that relate directly to the course content, tell students that nobody knows the answer to the question, and then challenge them to get involved in contemporary mathematics.

About institutional culture, I hear senior faculty and administrators telling junior faculty: If you want tenure, make sure that your research comes first. Yes, you must teach well, but your research is most important. You can do the educational things later.

This is troubling, especially given the situation in the mathematical sciences. For centuries, all we have had at our disposal in the classroom was a blackboard and a piece of chalk. Now, in many areas of mathematics, the computer is creating a whole new research and educational environment.

Mathematics now has a truly experimental component. In my mind, these changes need to be brought into the classroom. For the most part, it is not the older faculty who are poised to implement these changes. It is our younger colleagues who have the most to offer in this regard. It concerns me deeply that they are not encouraged or rewarded for their assistance in these matters. Indeed punishing them for this service is bizarre.

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ARTHUR B. ELLIS

MELOCHE-BASCOM PROFESSOR OF CHEMISTRY
UNIVERSITY OF WISCONSIN-MADISON
2001 DTS AWARD

Probably that we have a lot of fun and that we find a great deal of synergy in our research and educational activities. We keep many hands-on demonstrations in my office for visitors to play with, and use these to talk about the frontiers of research and technology. Our labs are a mix of research instrumentation and instructional products in various stages of development.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

[Thinking about institutional culture], here should be general understanding that the educational enterprise needs to be the same kind of moving target as the research enterprise. We take it for granted that there are always new advances in research, and this spirit should characterize education, as well. If we want the educational enterprise to have the same kind of vitality as the research enterprise, and a commensurate level of scholarship, this can be accomplished by continuously infusing our curricula and outreach activities with the latest exciting developments in research and technology.

A shift in institutional culture that promotes this philosophy will encourage more faculty to explore opportunities for integrating research and education in their careers and will lead to new paradigms for how this can be done.

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EVELYN HU

DIRECTOR OF CALIFORNIA NANOSYSTEMS INSTITUTE, PROFESSOR OF ELECTRICAL
AND COMPUTER ENGINEERING - UNIVERSITY OF CALIFORNIA, SANTA BARBARA
2005 DTS AWARD

For the classroom, an environment that encourages questions, that solicits opinions from students, and that tries to being in real-world experiences. I believe that education and research are inevitably linked and coupled, that doing "real things" and engaging in discovery is one of the best ways of catalyzing education—that seeing ideas take seed and develop, whether in a student in the classroom, my office, or in the lab is one of the greatest rewards an academic can receive.

The risks in trying new ideas in education are (as with anything) that the ideas and approaches do not work; they fall flat—whether because of some critical underlying assumptions were incorrect (what is valuable, what is interesting, what skill are required) or the resources were not sufficient, whatever. But that is a small risk to try something that could work, could transform the classroom and education.

[The DTS recognizes advancing the frontiers of education]. I believe that education and research are inevitably linked and coupled—that doing "real things" and engaging in discovery is one of the best ways of catalyzing education—that seeing ideas take seed and develop, whether in a students in the classroom, office, or lab is one of the greatest rewards an academic can receive.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

CHRIS IMPEY

UNIVERSITY DISTINGUISHED PROFESSOR OF ASTRONOMY
UNIVERSITY OF ARIZONA
2002 DTS AWARD

The most important impression would be that learning is a dynamic process, that teacher and learner must both be engaged, that all knowledge must be challenged before it becomes part of our world view.

There is a concept that has emerged from the study of artificial life—computational processes that mimic biological processes—that says that complexity and life evolve at the boundary between order and disorder. A classroom is full of complex interactions. If the pattern and order is too rigid, then students follow a preset framework and are not induced to think and question what they know.

This is like passively reading a textbook or content on the web. On the other hand, if there are too many tangents or too many interruptions to the flow, the result is chaos. The best classrooms combine a real sense of direction with a liberating freedom in the expression of ideas.

At most universities, the large lecture class will be with us for the foreseeable future. Luckily, there is a wide range of active learning techniques that can engage students in their own learning. I try to use as many as possible of these in my classroom—small groups, pair-share, preceptors, polls, and/or debates—these techniques work in almost any discipline.

In terms of astronomy, I hope a visitor to my classroom would get an appreciation for an ongoing intellectual journey. In just a few hundred years, we have used technology and the power of thought to transform the view of our place in the universe.

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LEAH JAMIESON

RANSBURG PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING
PURDUE UNIVERSITY
2001 DTS AWARD

What I hope they would leave with is a sense of learning by doing, the opportunity to deeply engage with exciting projects, and a sense of ownership. Engineers have a bigger opportunity in this area. There has been a big gap between the perception of what engineers do and the social awareness of engineering. Engineering and community involvement are words not often used in the same sentence. But the idea that engineers make things that help people—this is a powerful concept.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

[This began one summer when] a group of colleagues decided to spend time together doing what we should be doing and were not. It was an extremely close collaboration. We started looking in many directions—industry, in the news, from deans reports—that everyone was happy with the technical strengths in engineering of our students. But it was also clear that we [they] were lacking in the skills of communication, team-work, and on ethical issues. This was a few years before ABET, but the same messages were explicit.

There was another piece that made everything click. Our engineering students needed a different kind of education and community organizations were developing an increased dependence on technology but without the money to support it. [In pursuing these efforts}, the ties to the community and the openness of the community has been of value.

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GRETCHEN KALONJI

KYOCERA CHAIR, DEPARTMENT OF MATERIAL SCIENCE AND ENGINEERING
UNIVERSITY OF WASHINGTON
2001 DTS AWARD

I would hope that the visitor would hone in on the atmosphere of mutual respect and genuine affection that characterize most of my interactions with students, and that also characterize the interactions between students themselves.

Basically, I love being with them, and our goals are quite similar, so the atmosphere is collegial, with a good deal of humor in evidence. I believe visitors would also note that students are willing and able to take intellectual risks, and to take on a variety of leadership roles.

The major risk is burn-out. This work, while tremendously rewarding is very hard, as it represented quite a fundamental re-definition of the work of faculty and students. In my case, this is compounded by the fact that my personal research has tended to by quite abstract and not the most naturally suited to projects [I work on with students]. So I have had a number of parallel lives.

We need institutions to be willing to take big risks, and support pilot projects that fundamentally challenge what we are doing now. Clusters of faculty need to be supported over sufficient durations to time so that new models have a chance to prove themselves. So much of the educational innovation that is encouraged is more or less making adjustments on the margins. We also need more focus on supporting groups of faculty rather than individuals.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

DANIEL J. KLIONSKY

ALEXANDER G. RUTHVEN PROFESSOR OF LIFE SCIENCES
UNIVERSITY OF MICHIGAN-ANN ARBOR
2003 DTS AWARD

When I have had faculty colleagues visit my class, they usually express surprise at how the students are prepared to discuss the day's topic. They realize that this is one of the goals of my approach, but it is something else to see this in reality. For example, part of the course deals with the regulation of metabolism as exemplified by the lac operon. At the start of the corresponding class session I draw a line on the board representing the operon and ask the class to name the different segments. I then ask them to tell me the rules for which regulatory components bind and under what conditions.

Students taking a lecture course typically are not able to do this when they arrive for class because they have not done the reading or have not paid careful attention to the material; however, learning the parts of the operon and the rules for binding are a matter of memorization. There is no real need for me to read/relate that information to the students in the form of a lecture, and that is borne out by the fact that the students in my class are able to answer these straightforward questions about the lac operon when they walk in the door.

The real point is to see if they can now work with that information to determine whether transcription occurs under different nutritional circumstances. That is, do they understand the concept of regulation? Memorizing the components and binding sites is not important per se, it simply serves to give us a common language and starting point.

I can also gauge the students' comprehension during the problem solving and decide if they need additional problems on a particular topic or whether they are ready to move on. So to get back to the question, visitors are surprised to see that students in introductory biology can come to class prepared and that they are then able to answer questions or work through problems that are fairly advanced.

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MARY LEE LEDBETTER

PROFESSOR AND COLLEGE GRADUATE STUDIES ADVISOR, DEPARTMENT OF BIOLOGY
COLLEGE OF THE HOLY CROSS
2003 DTS AWARD

If they were students of Cell Biology in lecture, they would be closely attending to my presentation on the topic of the day, illustrated with microscopic images, video clips, and data of other sorts, linked closely to the exercises they themselves would carry out in laboratory. From time to time they would raise questions of clarification or of curiosity, linking the ideas to other areas of their learning.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

Different impressions would be gained from classes with different groups of students. If they were interdisciplinary College Honors students in our team-taught Human Nature course, they would see a lively discussion among opinionated, thoughtful students of various majors on a topic drawn from the week's reading, which might be Shakespeare's The Tempest, Karp's Speaking of Sadness, or Darwin's Origin of Species.

Cell Biology lab itself is much less formal, with students working in groups at their own pace, visiting, joking, and engaging me in conversation. In the research lab a visitor would likely be impressed by the seriousness and enthusiasm of the students as they learn to discover new knowledge for themselves. If the day were one where the experiments were not behaving, they would sense frustration and dogged determination; if it were a day of success, the excitement would be palpable.

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ERIC MAZUR

BALKANSKI PROFESSOR OF PHYSICS AND APPLIED PHYSICS
HARVARD UNIVERSITY
2001 DTS AWARD

I have a lot of visitors come into my classroom, often a delegation from another college or university. What they see, I think, is great enthusiasm– perhaps even chaos. They will see that the ball is not in my court, I see that I teach by questioning rather than by talking. This method of stimulating students to think can give a rather chaotic impression, but the students are thinking for themselves, rather than just transcribing what I might be thinking– or just starring into infinity and not thinking at all.

What we are about is using a strategy called "peer instruction," incorporating cooperative learning exercises into otherwise traditional lectures. Many visitors leave ready to try this approach, and over the past ten years, more than 350 other instructors– in different settings and disciplines– have successfully adapted our work.

Even though people sometimes say, "this can work for Harvard, but not for us," that is not the case. Students on campuses of all sizes and circumstances become eager to talk with each other, and we are finding that they can verbalize what they are learning better to their peers than to a seasoned instructor, who might be burdened by years of experience with being able to understand conceptual difficulties that students might be having.

What made me persevere was basically that I began to assembling data that documented that my students were learning better when I was using interactive methods. And now, with ten years of documented success from my classrooms, tog with data we've gathered from the almost 400 instructors around the world who have this method, not to persevere would be unconscionable. I never saw this risks, only the rewards. One day, when I was asked a question by a student that I did not know how best to explain, 100+ students started responding to here, in true peer instruction. That was reward enough.

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WILLIAM MCCALLUM

PROFESSOR OF MATHEMATICS
UNIVERSITY OF ARIZONA
2005 DTS AWARD

I had an opportunity to observe myself teaching recently, through a videotape of a class I taught to University of Utah math majors planning to become high school teachers. The thing that interested me as I looked at these tapes was how much care it takes to get students to pay serious attention to the ideas of mathematics, particularly in algebra. Students are accustomed to thinking of algebra as following correct procedures, not reasoning about numbers. When you do manage to open their eyes to the revelation that the symbolic language of mathematics.

I first got interested in mathematics education through my involvement in calculus reform in the 90s, as an author of the texts produced by the calculus consortium, which was at that time based at Harvard University, where I had been a graduate student. I had always been interested in teaching, but at that time saw myself primarily as a research mathematician. That project, and other later ones, became a large part of my life, so that I have ended up living in two worlds, so to speak.

Since I started my work on undergraduate education before receiving tenure, there might have been risks, but in fact I was fortunate enough to be in a department with a long tradition of serious attention to teaching and scholarship about teaching. The main challenge for me has been to find the time to continue both my research program and my work in education. Perseverant was not a problem, in fact I have always found it refreshing to be able to switch to the other current when one began dry up. But it is an unsolved problem for me to get more hours in the day and more days in the week.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

RICHARD A. MCCRAY

GEORGE GAMOW DISTINGUISHED PROFESSOR OF ASTROPHYSICAL AND PLANETARY
SCIENCES - UNIVERSITY OF COLORADO AT BOULDER
2002 DTS AWARD

S/he would notice that, the students are much more visible than in a traditional class. I don't lecture much. I spend most of my time probing what students have learned and working through their misconceptions. Students are expected to come to class with prepared answers to questions that have been posted on the class web site.

Often, students will disagree. On the best days they engage in heated debate. We don't try to cover as much material as in a traditional lecture session. I try to run a student-centered classroom. So they do most of the work.

If one is going to make a serious attempt at innovation in undergraduate education, it's not a risk, it's a certainty that the effort is going to cost a great deal more time than carrying out one's teaching duties in the conventional way. Innovation in education is like any experimental science. If you don't risk failure, you aren't pushing the envelope.

So I try a lot of things. Some work, others don't. Most students are pretty conservative. They have certain expectations of what a college science class will be, and they feel stressed when they have to deal with an unconventional format or unconventional expectations. For example, many students become uncomfortable when they see that they are expected to answer a question in the presence of 200 other students. And many students are surprisingly resistant to collaborative work. They want to study on their own, and they don't want other students to know what they are learning (or not learning). It's a very interesting challenge to find ways to overcome these barriers. I think the key to effective innovation is to build a lot of feedback mechanisms into the course design. That enables one to discover and correct mistakes very quickly. Also, I have found that students will cut me a lot of slack if they know that they are participating in worthwhile experiment, and that I am prepared to respond quickly when they run into difficulties.

The most effective feedback mechanism that I have found is the use of undergraduate learning assistants. Students in the class see them as peers and are much more open with them about what they like and dislike than they would be with me or a graduate teaching assistant. I meet with the learning assistants every week. Through these meetings I gain a much better understanding of how students are responding than I could otherwise.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

KEN ONO

OLIN PROFESSOR OF COMPUTER SCIENCE
UNIVERSITY OF WISCONSIN-MADISON
2005 DTS AWARD

The visitor would note the active involvement of all members of the research team. The students are not afraid of asking `dumb questions', and they work late. Basically, I hope that the visitor would be impressed by level of energy in the research team. [I connected my research my efforts to advance the frontiers of education because], unlike the experimental sciences, pure mathematics is a subject driven by ideas and proofs. People offer proofs, and so we must invest in new talent by providing research opportunities for enthusiastic students of all levels. Educating students, at all levels, comes quite naturally with research in pure mathematics.

I have not taken any risks [in doing this]. It has always been my practice to actively engage students of all levels in my research program. My students have been honored for achievements in many ways. Some have won medals representing the US in the International Mathematics Olympiad, some have won prestigious awards, such as the Westinghouse and Intel Science Talent Searches. Those successes are documented by the quality of science that the students have produced.

The DTS program is a fantastic vehicle for motivating scientists to consider the prospect of amplifying their educational activities. With this award, I am working closely with the American Mathematical Society in its "Who wants to be a mathematician?" outreach program. This program is a nationwide traveling game show which is modeled after the famous television program "Who wants to be a millionaire?". I will also offer annual "Summer Institutes" at the University of Wisconsin for talented high school students and undergraduates. These students will be actively engaged in research in number theory.

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JOSEPH O'ROURKE

OLIN PROFESSOR OF COMPUTER SCIENCE
SMITH COLLEGE
2001 DTS AWARD

A good portion of the work I do with students is indistinguishable from play: We tape bent straws to the table, cut out shapes with scissors, build poly-hedra out of playing cards, and puzzle over images rotating on a workstation screen. Most of the work is fun, and when we feel close to a discovery, exciting. I should add, however, that the norm is a state of mild befuddlement, a state one grows used to in research.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

The risk was to invest so much thoughts, time, and energy in a proposal [to NSF] so unlikely to be funded. In the longer term, there is no questions that time spent on education generally does not push the frontier of research. However, it is nearly a personal quirk of mine that I only achieve through understanding of an area by reaching the mastery necessary for exposition. Thus my educational efforts, documented in my books and expository articles, have helped my research.

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SUSAN E. POWERS

PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING
CLARKSON UNIVERSITY
2004 DTS AWARD

What I am passionate about is using projects to stimulate an "interest in actually learning" in all my students. When I began teaching, I thought about my own high school experience, realizing that what I remembered and valued was the learning that I could see visually. Based on those high school memories, I was drawn to hands-on, active project-oriented learning.

During my first year at Clarkson University, I had the opportunity to work with another new faculty member on a design competition focusing on hazardous waste with college-level senior students. This new course consumed much of our time, but it reinforced my understanding of the value of project-based learning.

My approach in the classroom is to use a specific, real-world project as a springboard getting students to dive right into problems, and once they are immersed in the problem to backtrack into learning the science and the engineering needed to tackle the project and to succeed in making it work. Although I don't use this approach in all of my course work, as I began to see its impact on my undergraduate students—how they learned better, I began using it to work with middle school students, through the GK-12 program funded by NSF to our campus.

As an environmental engineer, devoting much of my work to the environment, I recognize that many of our environmental problems are related to energy usage. I believe that if we can do something to change the way we use energy, we can reduce the environmental impact of energy usage. In fall 2000, I conducted a project-oriented course on gasoline and groundwater for sophomore honors students. The students and I examined transportation fuels, asking where do they come from, what is their impact on the environment?

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

Overall, the administration has been supportive of project-based learning and has established the SPEED (Student Projects for Engineering Experience and Design) program, which offers institutional and fiscal support for our engineering students to participate in design competitions and curricular and extra-curricular activities.

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JULIO J. RAMIREZ

R. STUART DICKSON PROFESSOR, DEPARTMENT OF PSYCHOLOGY
DAVIDSON COLLEGE
2004 DTS AWARD

"Wow, that was a high-energy lab!" Our laboratory environment reflects our eclectic approach to neuroscience, which is a mixture of neuroanatomy, neurophysiology and behavior. The laboratory walls are adorned with a collection of prints ranging from Georgia O'Keefe to "Techno-Brain" and the rooms are filled with music ranging from Amadeus Mozart to Brandy to Paquito D'Rivera.

In one corner of the lab, a senior majoring in neuroscience will have been teaching a sophomore psychology major how to properly place a coverslip on a section of brain tissue attached to a glass slide. Across from them, the lab tech will have just finished running a histochemical reaction on brain material from one of our experiments. In the adjacent room, which houses our microscopy laboratory, a pair of junior biology majors will have been analyzing brain sections on our image analysis system and a senior psychology major with a neuroscience concentration will have just completed reading a paper relevant to our research effort.

Pursuing this educational approach was challenging at times, particularly when grant reviewers and colleagues were less than enthusiastic. As an educator, I came to rely on my experiences as a researcher. One of the attributes for a successful scientist is having "thick skin." Every scientist knows that teasing the truths out of nature may take persistence and experience. After extensive toiling and some clever cajoling of nature, the truths may flow from the research, but one must be prepared for the possibility that a truth may be a rejected hypothesis. The lessons I learned as a researcher informed my efforts to risk failure while seeking to improve the educational experience of my students and the strengthen the support of the faculty educating them.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

CHRIS ROGERS

PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING, TUFTS UNIVERSITY
TUFTS UNIVERSITY
2003 DTS AWARD

I would hope that the visitor would leave with a better understanding of fluid mechanics or robotics. I would also hope that the visitor leaves curious and interested in learning more. As to the impression of the class itself—I am not sure—probably that the students are enthusiastic and the class is slightly chaotic.

[How I got involved with this is that] it seemed natural. I was excited about the research and the teaching—so it makes sense that they would merge. Not all my research overlaps with my teaching—and many of my more "unique" teaching techniques have little to do with my research, but I find innovation in teaching just as exciting as innovation in research.

With any "new" approach, people are always a little surprised, and spending time on teaching was more of a "risk" before I was tenured since innovation in teaching does not carry the same weight as innovation in research. My university has always been very supportive with all of my innovations. Some of the material has been documented in the ASEE journal and other places

My advice to faculty at an early career stage is to remember that the personal life is very important and should not take a back seat to the pressures of getting tenure. One should be a professor for the love of teaching and research—if one is working too hard to enjoy it, then something is wrong.

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HARRY L. SHIPMAN

ANNIE JUMP CANNON PROFESSOR OF ASTRONOMY
UNIVERSITY OF DELAWARE
2003 DTS AWARD

Visitors are often surprised they are asked to work, not just visit sitting in the back row. A few years ago, Steve Sobek, a local newspaper reporter, sought to do a profile on me and asked to visit my "Science and Religion" class. I asked him to sit with a group, and hopefully, contribute to the group discussion. Each of my classes is a combination of some teacher-talk and some group discussion.

Visitors usually leave with the impression that students' minds have been engaged in whatever issue, problem, question, or task their group has been assigned. They realize that a noisy classroom—students talking to each other—is often a sign of successful teaching (as long as the students are on-task).

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

I haven't stopped lecturing. There are uses for lecturing, but simple delivery of information that is otherwise available in a book or on the web is not one of them. Most of the time, I do lecturettes (15 minutes or less) instead of lectures. My educational research—and that of others—shows that for a wide variety of audiences, attention fades after about 15 minutes.

There are risks, two kinds of risks [in doing this]. First there's a risk to the student. Whenever you set students to work in groups, the groups end up controlling, to some extent, what the class does. When I invited the reporter to sit with a group in my class, I hoped the group would stay on task and learn what I intended. They did. When you shift the responsibility of learning to the students, it becomes pretty obvious when a teaching sequence does not work.

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LEE SPECTOR

DEAN, SCHOOL OF COGNITIVE SCIENCE, PROFESSOR OF COMPUTER SCIENCE
HAMPSHIRE COLLEGE
2003 DTS AWARD

On a good day students would all be "doing their own thing" to a large extent, consulting with me and with each other from time to time. My primary pedagogical strategy is to encourage individual engagement with open questions that students find personally captivating. I prefer to attend to elements of the standard curriculum later, as needed to support project work, after students are actively engaged in projects of their own devising. This can be difficult to arrange in a classroom setting, and sometimes my classes are more conventional and oriented toward large groups than I would prefer—but immersion in projects driven by individual student interests is usually my goal.

I find that my own understanding of the issues on which I conduct research is most dramatically improved when I try to explain or to demonstrate them to others—particularly to others with little related experience. I find the development of such explanations and demonstrations (many of which involve interactive activities) to be an extremely stimulating creative challenge. When I am successful the resulting activities serve simultaneously to clarify my own thinking about the research interests and to convey the substance of the issues to my students. In the ideal case the students will also be "infected" with some of my excitement about the issues and will develop enthusiasm to explore them further.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

Experimental and novel explanations, demonstrations and activities will not always be successful. There is always the risk that they will fall flat. The conventional, well-tested approaches are certainly safer, but I try to avoid them both because I know there are alternatives with greater potential and because I find conventional approaches to be boring (both to me and my students). I am most engaged when I am trying to innovate, and I find that this engagement often translates in student engagement.

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KENNETH G. TOBIN

PRESIDENTIAL PROFESSOR, URBAN EDUCATION
CITY UNIVERSITY OF NEW YORK (CUNY)
2004 DTS AWARD

My research and teaching are very much aligned with my twin passions of science education and urban education, thus a visitor would have to follow me to many different settings. My research is situated in science classes in public schools in Philadelphia and New York City, and my approach is to include in my research the goals and perspectives of K-12 students and their teachers and to collaborate with them as co-researchers.

At the same time, I participate in their classes as a co-teacher, a collaborative approach that necessitates my presence and active participation in the teaching and learning of science in elementary, middle, and high school classes. We use a variety of data resources to learn from this collaborative research: video and audio recorders to obtain digitized records of interactions that occur during learning; and collecting and studying artifacts from classrooms in which we undertake our research.

Beyond class time, we discuss what happened with teachers and students; then, the visitor would see that in our research lab, we do intensive analyses of data resources, using digital media and software tools that allow us to study discourse and video images intensively. Thus, just as the teaching is collaborative, so too is the analysis and interpretation. Our collective goal is to obtain insights into how the quality of science education can be improved in public schools in urban areas.

The greatest risks for my research in science education have involved the uses of different theoretical frameworks and methodologies. Whereas it was very apparent to me what was needed to be done at each step in a continuous program of research that has extended beyond 30 years, colleagues often were not ready for the changes nor aware of the need for them.

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If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

NICHOLAS J. TURRO

SCHWEITZER PROFESSOR OF CHEMISTRY, DEPARTMENT OF CHEMISTRY
COLUMBIA UNIVERSITY
2002 DTS AWARD

A visitor would find a group of students who are in a learning process in which one of the most engaged students is the instructor. I've always felt that to be an effective teacher you've got to get into the head of the student and try to understand the arduous process of learning a subject. I'm a fan of the notion that we create our own knowledge best by a combination of distributed learning in groups as well as the hard work of scholarship, reading extensively and practicing with relevant problems.

To me, the learning experience involves a process that is independent of content. Good teaching and learning integrate content with context and cognition components. An effective teacher employs the integration explicitly or implicitly. The context is connecting the content to issues that are important to the student and provide a motivation for the student to learn. The cognition component provides a set of intellectual techniques that are powerful for learning in general, like peer interactions in learning, active learning, and student responsibility for learning.

In my laboratory I hope that the visitor would notice that the principles of effective learning were being transferred to the research training and mentoring experience. My students work on both individual and collaborative projects. The importance of peer interactions and exchange of information and technical expertise are stressed. The visitor would find a research supervisor who is also a mentor with a concern for the development of each student as a person who will develop into a scholar, a professional and a researcher.

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CARL E. WIEMAN

DISTINGUISHED PROFESSOR OF PHYSICS
UNIVERSITY OF COLORADO-BOULDER
2001 DTS AWARD

I am not sure what impression they would leave with, but I can say what impression I hope they would get. I would hope they would see a bunch of students interested in what they are learning and taking a lot of responsibility for figuring out physics and how it applies to the world around them. I do know that, compared to many other physics classes I have observed, a far larger fraction of the students in my "lectures" are awake, paying attention, and asking questions, so I may not be hoping entirely in vain.

I would not say that my research per se brought me to a concert with education. However, I am a hard-core experimental physicist, and so I always believe that it is absolutely essential to have an unbiased evaluation of what the data are telling you. I have learned that it is very important to see what is really there when you do an experiment and not simply see what you are looking for. It became increasingly clear to me that when evaluating the effectiveness of most physics teaching, if one stripped away the triple biases of ancient traditions, how we were taught as students, and what we wanted to see, the results looked pretty dismal.

The combination of these factors drove me to tackle the challenges of improving physics education. Perhaps the closest contact with my actual research was that it allowed me to look carefully at how and why students in the research lab learned so successfully, and so I could use this information to attempt to get something of those same factors into the completely different environment of the classroom.

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DEAN A. ZOLLMAN

DISTINGUISHED UNIVERSITY PROFESSOR OF PHYSICS
KANSAS STATE UNIVERSITY
2004 DTS AWARD

His/her impression would depend on the topic, the type of students and even where we are in the learning process about a particular topic. I tend to vary the learning experience considerably to meet the needs and objectives at the moment. In most cases I would hope that the visitor would come away with the impression that the students are learning rather than I am teaching. That is, the students are actively engaged in a process that leads to better understanding of the principles of physics rather than me telling the students what they need to know. However, occasionally, the learning process is best dealt with by providing information for the students.

So, a visitor who came to the class several times would see several different methods of learning and teaching. I would hope that the overall impression is that I modify the learning process to work best with the situation at hand and that the style of teaching and learning changes frequently.

I am somewhat different from most DTS Awardees in that my research is about the teaching and learning of physics. Thus, connecting the research and learning/teaching was automatic. I became interested in this type of research when I first had the opportunity to teach a physics course for non-science students. I was amazed at how little they were learning. After I got past blaming it on them, I began to become interested in why students had difficulty learning physics and how we could improve the situation. Now, for over thirty years, I have focused on trying to understand students' learning in physics.

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DAVID BILLINGTON

PROFESSOR OF MATHEMATICS
PRINCETON UNIVERSITY
2003 DTS AWARD

Let me respond just to your first question, *what would a visitor to your classroom experience?*

My classes, all lecture courses- two with large lecture courses of about 150 students- are entirely visual. They are open to all students in the university and are designed so that students leave with a set of images in their heads of the "grand tradition of engineering." My goal is to introduce my students to major engineering innovations and to the thinking of outstanding engineers; what I demand of my students is that they will be able to demonstrate (numerically and through expository writing) that "efficient, economic, ethical and aesthetic choices are all intrinsic to engineering design."

In my course on structural engineering, the lectures and visual images are designed to illustrate that structures, when designed by engineers, can be both beautiful and economic– what we call structural art. I hope they leave this course with a new interest in looking at the environment and for seeking out and judging for themselves large-scale engineering projects.

The goal of my other course also open to students in all engineering fields and to students studying in fields outside of engineering is that students arrive at an understanding of how engineering has transformed the United States from an agrarian society into an industrial one. All students work through and learn how to make the same calculations as did the early engineers, and are introduced to the connections between building structures and building societies.

In developing three courses in introductory engineering, I had to consider that all courses are open to everyone in the university, and I found that the "scholarship" needed to develop them was much more challenging than that needed to work on courses for upper level majors or graduate students (it is much easier to connect these students to my research). The way it worked for me was that I was stimulated to step back and analyze how I was introducing students to engineering; when I was teaching architectural students, they would ask, "Why is it all just diagrams and drawings? Why can't we study beautiful things?"

I was stimulated into a new line of scholarship by bad teaching. I could find nothing in the literature that began to analyze "beautiful things," the engineering structures that are indeed good structural art in that they combine safe performance and competitive costs while simultaneously achieving elegant forms that surprise and please visually. All of my lectures are conceived as public lectures, growing out of or leading to a scholarly publication. Thus to say that I am integrating research and teaching is not quite right; I cannot make a distinction about which comes first.

If a visitor were to come into your classroom/lab—the environment in which you work with students—what impression would s/he leave with?

It is the visual nature of my work—my lectures and courses—that shape the project supported by the DTS award. Just as for my undergraduate students at Princeton, I want to give other scholars first-hand experiences with the materials, I want to transmit in person how through an examination of engineering structures one begins to dissolve the artificial boundaries between scientific, social and artistic world.

This material is exceptionally seductive, once you see it, and this kind of examination must be facilitated in face-to-face interactions; it cannot be done by placing a lot of materials on the web and hope others begin to understand their import. So, back to your original question, which I will rephrase: what would be the impact of coming into my classroom?

For the casual visitor, for my undergraduate and graduate students, and for scholars participating in the NSF-funded DTS summer workshops, I repeat what I said earlier in an interview on Bridging New York for Great Projects:

> *We live in an engineering culture. And it's important for [all of us] to see that engineering, in its true meaning, is really an integration of science. . ., of society. . . and of art. . . .*
>
> *And. once they see this, then we can begin the process which we so strongly need in our country, of the reintegration of knowledge, of combating the fragmentation and specialization that has forced discourse into separate boxes and that does not allow, therefore, the technical to think about the aesthetic, or the political to think about the technical.*
>
> *And when those in my classrooms understand that in order for the best structures to be built, the designers had to think about all these things, they will begin to put engineering and technology into a different context, not as a special school like all other professional schools in a university, but as part of the central core of understanding that is so essential to our society.*

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