NETWORK OF EDUCATORS IN SCIENCE & TECHNOLOGY

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Contents

Co-Chair Report

Building STEM Bridges through Global Impact

Andra L. Zoller [NEST '03]

Where were you when you received the notification that you were selected to attend the Science and Engineering Program for Teachers (SEPT)? I received the letter through the mail and was too nervous to open it initially. I held the MIT envelope up to the light above the breakfast room table. Trying desperately to read the message through the filtered light, I cautiously set the envelope aside and was extremely apprehensive about the message

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An Interview with Sheila Tobias and Anne Baffert: Authors of *Science Teaching as a Profession*

Sheila Tobias is a political activist with a degree in political science and is an author of books intended to demystify mathematics and science for students, teachers and policy makers (along with a variety of other topics). Anne Baffert has many years of experience as a high school science teacher in public and parochial schools and is currently the chair of science at Salpointe Catholic High School in Tucson, Arizona. They are the coauthors of *Science Teaching as a Profession: Why It Isn't How It Could Be* (2009), which is mentioned elsewhere in this issue. (The project was supported by Research Corporation for Science Advancement, a non-profit Foundation in Tucson Arizona.) This article is the result of a three-way phone interview the editor had with them on Sunday, August 30, 2009.

As an opening question, they were asked:

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Those Who Can't Do, Teach

Julianne R. Opperman [NEST '97]

During a ferocious battle between the district teachers and a school board over time and money, one arrogant board member actually stated the title of this article in a public meeting. I recall the moment vividly. I was standing at the back of the cafeteria listening meekly, since I was as yet not a tenured teacher. I muttered and mumbled and grimaced, making eye contact with a more senior teacher who shrugged and raised her eyebrows. The memory still rankles me.

The point of my words here is not a result of reliving a moment in my teaching history, but to articulate what I see as my teaching future, and perhaps that of others.

This article began as a review of a small book I picked up at the MIT Press bookstore, *So You Want to Be a SCIENTIST?* by Philip A. Schwartzkroin. The author quickly gives the reader an overview of the life and livelihood of a scientist from graduate school onward. He briefly discusses the thinking, writing and talking a scientist does. Schwartzkroin enlightens the novice on the ethics, politics, responsibilities and personal challenges a scientist will encounter in his or her career. His purpose is to let the would-be scientist know that doing science is a social enterprise. Choosing the specific field of study is important, but no matter the level of scientific interest, science is done in society. Colleagues, collaborators, funding providers, institutional administrators, the government and the disposition and needs of society are factors influencing a scientist's fulfillment in his or her chosen career. The book is an easy read and, while aimed at a university undergraduate, it is entirely appropriate for a serious high school student.

As I read the book, I realized I am still a research scientist by training. In the university

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Calendar of Events

January 16
NEST Executive Board Meeting (Co-Chair and Representatives are nominated)

January 29
Deadline to send letter of interest to Jennie for Research Experience for Teachers (RET) 2010 at MIT

January 30
Invitations for Teacher Awards are sent out via email

February 12
Invitations for McNamara Workshop proposals are sent out via email

February 12
Invitations for Student Awards are sent out via email

March 1
Submission deadline for the Spring NEST newsletter

April 2
Deadline for 2010 SEPT Applications

April 9
Deadline for registering for the Summer 2010 NEST Reunion/Retreat

April 16
Deadline for nominations for McNamara Workshop Proposals and Student Awards

April 28
Deadline for online votes for Co-Chair and Representative

May 3
Student Award books and certificates are sent out to nominating teachers

June 24-26
NEST 2010 Retreat

Editorial

I was surprised to learn that less than half of the NEST members gave out NEST Student Awards last year. This program, designed back in 1991, is to recognize students that meet the following criteria:

- The award is given to a student who, through personal initiative, has done the most to promote awareness of science or technology.
- The award recognizes not only what the student has accomplished, but the future potential of that student.
- Student initiative in either the school or the larger community should be a very important consideration.
- The award does not necessarily have to be given to the student with the highest rank.
- The award is not restricted to any one grade level.

One misconception that must be addressed is that this award is not a competition between schools. While the application refers to nominating a student for the award, if the program is taken seriously and the application is filled out completely, the student will receive the award. The application will require a nomination statement that is at least one paragraph in length, stating the reason why the student should receive this award.

A school receives a plaque the first time it participates in this program. In addition, the student will receive a certificate and an autographed book. [Originally, when the program started, a second copy of that book was also given to be placed in the school library.]

Every school in which one or more NEST members work should be awarding a student every year. The form will be sent to all NEST members via email in January and the deadline for submitting the form is April 1st. Be sure to follow up on this. In addition, it does not hurt to start thinking of a possible recipient as the year progresses. ❅

Serendipity

"Where observation is concerned, chance favors only the prepared mind."
—Louis Pasteur, 1854

[Despite the clearly organized, sequential pattern of the "scientific method," many great advances in science have NOT followed that pattern. They were due to tangential aspects of the research or accidental discoveries that were noticed by researchers with prepared, observant minds. This column shares such fortuitous accidents with you so that they then may be shared with others—especially students—to gain a better, more honest picture of how science has progressed. Perhaps it may alter their attitude in the lab, looking at what actually occurs, rather than just looking for what they expect will happen.]

It was 1875. A scientist woke up during the night due to pain from a finger cut he had gotten the previous day. He went downstairs to his chemistry lab and placed some collodion on it and went back to bed. Collodion is commonly used as a surgical dressing or to hold dressings in place. It is made by dissolving cellulose nitrate in ether and alcohol.

He woke up an hour later, around 4 in the morning, when the coating flaked off. The ether in collodion evaporates forming a gelatinous mass and, by itself, it had nothing to bind to over the cut. Going back downstairs, he thought about this and about the chemical make-up of collodion. He tried adding a few drops of nitroglycerin to the gelatinous mass and found that they dissolved.

His curiosity led to experimenting by varying the proportions he combined together. Working with nitroglycerin may sound strange, as it explodes on concussion or when suddenly exposed to heat, but he had previous experience with that chemical. The result was the discovery of a chemical that is safe to transport and is mainly used in mine blasting. Unlike dynamite, gelignite—also called blasting gelatin—does not *sweat*. That is, it does not release unstable nitroglycerine.

The scientist was Alfred Nobel.

If you have not yet read *Science Teaching as a Profession: Why It Isn't as It Could Be* by Sheila Tobias and Anne Baffert (excerpts are on page 4), you can download it at http://rescorp.org.

Contact **Steve Cremer [NEST '90]** at scremer@usfirst.org for information regarding FIRST (For Inspiration and Recognition of Science and Technology). As part of his work, Steve is developing a business energy auditing program for high school FIRST teams to use as a fund raising tool for their teams.

Kathy Segale [NEST '08] gave an interesting presentation at the NEST Retreat entitled "The Richness of Pascal's Triangle: Number Patterns, Probability and Algebra in an Ancient Triangle of Numbers." Those who were unable to attend the presentation are encouraged to contact Kathy for a copy of the Power Point, as you will be surprised how much can be extracted from this numerical pattern. Her email address is KASegale@aol.com.

Avi Ornstein [NEST '89] has a website at www.aviornstein.com. The site includes a weekly puzzle (plus the solution to the previous puzzle) and an article on education that changes every 3 to 4 weeks. Let other teachers who might find it useful be aware of it.

Alternative Assessments in the Science Classroom: Reaching the "YouTube Generation"

Kim Eberle-Wang [NEST '08]

As a teacher of high school science and a parent of two teenage sons, I straddle the generations between my own parents who are unaware that YouTube exists and today's 17-19-year-olds, the so-called Millennial Generation, who keep the site perpetually open on any computer on which they are working so that they can access video clips of their favorite bands and comedians while simultaneously doing homework, filling out college applications and posting social updates on their Facebook pages. What's a scientist-mother to do to divert their attention for a "teachable" science moment?

One idea came to me after I was fortunate enough to receive a set of classroom MacBook Laptops for my new science lab/ classroom. These laptops come with two very popular and useful programs preinstalled: iPhoto for downloading and processing photographs and iMovie to record, edit and export videos. It took my students about 5 seconds to notice these programs and to begin using the embedded video camera to take still photos and videos of themselves. Writing a traditional lab report is important because it requires students to practice hypothesis testing and formal scientific writing skills, as well as graphing and interpreting their data. Important, yes, But for many of today's high school science students, writing a traditional lab report is about as exciting as a visit to the dentist. My goal was to incorporate a YouTube style video to complement one of my science labs. This would allow students to practice their visual presentation skills, as well as audio and video editing to produce a video version of a traditional lab report that could be posted on YouTube for public or private viewing.

To this end, students in my pharmacology elective course were placed in groups of 3-4 individuals with two MacBook laptops. Each group represented a drug development team. A series of guided questions from a PowerPoint file on their laptop directed them to name their drug company and to come up with a method of testing various known drugs and natural substances for their antibiotic effects. The students were given about two weeks to do background research, brainstorm a reasonable procedure, set up an assay with appropriate controls, photograph their procedure and results, graph their results and make a video depicting a commercial supporting the efficacy of their naturally derived antibiotic. Some natural substances tested included: honey, tea, tree oil and lemon juice.

In any group project, there is a temptation for some students to "coast" while others do most of the work. Therefore, the students were given a grading rubric at the onset of the project to clarify how they were to be evaluated on their daily progress and the completed product, as well as their individual effort levels during class time. The most successful groups were able to allocate their time and tasks and incorporate textbook concepts, such as antibiotic resistance, while also including humor in their videos, where appropriate. White lab coats and stethoscopes were shared as props so students could "play doctors" in their pretend T.V. commercials.

When surveyed at the end of the course, over 95% of my students noted that creating and posting their 2-3 minute pharmaceutical commercials on YouTube was their favorite part of the course. Their test scores also indicated that they had mastered the details of the material. I practiced learning the iMovie software myself by making a short video about my course so that I could help them with the sound and image editing. Not only does iMovie make it easy to edit video clips and to enhance them with additional sound, text and photos, but the "Share" menu allows you to export your finished product to YouTube with relative ease after you have set up an account on www.youtube.com. If you have any difficulty doing this, I suggest that you ask your favorite 14-20-year-old for some help. My 14-year-old son, Jordan, was a big help as were some of the students in the course who were part of the Springside iSITE group, Springside Students for Innovative Use of Technology in the Classroom. To learn more about our student technology mentoring group, visit them online at www.springside.org/home/content.asp?id=5545.

Overall, I think that the experience was my favorite part of the course as well because I got to appreciate the creative side of my students. Structure is important when embarking on this type of project, so setting a definite time frame with landmarks is important, but the rewards are many. I will definitely revisit their project when we learn about antibiotics again this year.

To learn more about the pharmacology elective at Springside School and to see a sample student antibiotic lab video, you can visit mitnestpharm.ning.com. If you have any specific questions, I would be happy to answer them. I can be reached at kwang@springside.org.

Professional Educators

[These excerpts are from *Science Teaching as a Profession: Why It Isn't as It Could Be*, by Sheila Tobias and Anne Baffert.]

Our proposition is simple but revolutionary. Until and unless science teachers are given back substantial control of the subjects they teach, including curriculum content, pedagogy, pacing and assessment, and successfully recruited into leadership at the school, the district, the state, and the national levels, we won't have robust student achievement.

There is no question in our minds and in the minds of the teachers contacted over the past two years that teaching *is* a profession or that it could be one if reforms are implemented. What is our evidence? Teaching involves mastery over complex bodies of knowledge, licensure by a legitimate authority, renewal through continuing education, and responsibility for young, vulnerable minds. Moreover, like doctors and lawyers, teachers are visibly responsible to a wider public, morally committed to public service, and capable of setting and policing standards for practice.

In this age of educational accountability, tests—often multiple-choice—are being used as the measure of schools' and teachers' effectiveness. But when these tests are designed by non-science teachers (even by non-teachers), and when the exam items fly in the face of inquiry-based science, then teachers lose one of the most fundamental aspects of professionalism: *the power to determine their own efficacy*. Though teachers may still design and administer classroom assessments, these results are dwarfed by the "all-important" state science tests.

When teaching truly becomes a respected profession, schools will be able to attract many more academically qualified candidates and be able to retain experienced teachers as well.

Too many decisions about what is done in the classroom are made by people who never set foot in a classroom. Science teachers have very little say in the important decisions made on hiring, evaluation of teachers, school policies, schedules and class size. More importantly teachers are starting to lose control over what and how they teach and how they are assessed.

… as their range of instruction narrows (and with high-stakes testing it will narrow still more), science teachers may be forced to sacrifice everything they and their students love about science for a regimen of drill-and-practice. Their responsibility to their schools and their school districts will demand that.

But what of their responsibility to the nation's desperate need to replenish its science workforce? And to the next generation of science teachers? And to their own professional integrity? Who will be watching out for these? ❅

Worthwhile Websites

"The Underworked American" looks at the educational demands of our children.
http://the-economist.com/world/unitedstates/displayStory.cfm?story_id=13825184

Note-Taking Skills

Avi Ornstein [NEST '89]

Note-taking is a skill students need to gain to succeed in school and it is useful, if not necessary, in most professions. Taking notes helps them organize their ideas, lets them see if everything fits together and adds to the learning process. The quality of notes varies greatly, ranging from highly beneficial notes to those that are practically worthless. I found that students in my class should record at least five types of entries in their notes.

They are:

- Chapter notes
- Classroom notes
- Vocabulary
- Demonstration notes
- Lab observations

The first step to good note-taking is to do assigned reading *before* it is covered in class. It is not expected that the students will then know the chapter, but they will have been exposed to the terms. Taking notes while doing the reading is important, as many points will not be repeated in class.

In class, they need to try to get down notes on the ideas that are covered. They should *not* be trying to get down what is said word-for-word. It is important that they learn to use the time to listen and actually hear. As I learned in college, there is a need to develop the habit of later recopying this type of notes, making them neat, clear, complete and organized. Items that are not needed can be deleted. At the same time, they must be certain that what they do write down makes sense. By rewriting their notes, they are reviewing the material that was covered in an efficient manner.

They will now have a set of notes that can be used for reference and study, though the preliminary studying has already been carried out in creating them. The students also know which points are uncertain, so they can be resolved in class the next day. When they need to look something up in their notes, they are more likely to find it sooner when the notes are neat and orderly. These procedures are not guaranteed to work for everyone, but the odds are that they are far more likely to help than other methods most students tend to follow. Furthermore, they can work for any course.

Encourage your students to give it a try. If they don't like it, they can always modify it. If they don't try it, they will never know how much it may have helped them.

Another important aspect of note-taking deals with the vocabulary for a course. Many new words appear in most school courses and it is necessary for the students to know these words if they are to understand the curriculum. Merely copying definitions is of minimal value. They need to *understand* the words to be able to comprehend the reading assignments and what is discussed in class. When writing the definitions for vocabulary words, students should rephrase them in their own words. This requires them to actually understand the words, which is the real goal.

As a science teacher, when a demonstration is done, the students are expected to do more than merely be an audience. A demonstration is done for a purpose, and they are expected to take notes so that they will be learning from the experience and will later be able to refer back, when necessary. The same is even more critical regarding lab observations. They will later be used in writing actual lab reports, so carefully recording what is observed, whether qualitative or quantitative, is of primary importance.

Kudos

Bette Bridges [NEST '90], Betty Catelli [NEST '95], Harvey Gendreau [NEST '95] and **Cary Kilner [NEST '96]** were all presenters at Chem Ed 2009 at Radford University in Virginia.

Steve Cremer [NEST '90] entered his second year as the Massachusetts Regional Director for FIRST (For Inspiration and Recognition of Science and Technology).

Joyce Gleason [NEST '91] supervised career-changers in their student teaching experience at Florida Gulf Coast University.

Sandra Mitra [NEST '06] received a grant from the Gelfand Endeavor in Massachusetts Schools (GEMS) to establish and support a science fair at her school, which had not been held there in over 20 years.

Julianne Opperman [NEST '97] and Mya Poe of MIT coauthored the ninth chapter of "Teaching the New Writing: Technology, Change, and Assessment in the 21st-Century Classroom." The subject of this chapter is using technology to teach scientific and technical writing.

Avi Ornstein [NEST '89] was the 2009 Connecticut recipient of the Secondary School Chemistry Teacher Award, presented by the New England Institute of Chemists. In addition, his second book—*Sonia in Vert*—is now out.

While **Steve Rocketto [NEST '90]** has retired from teaching, he is now Director of Aerospace Education for the Connecticut Wing of the Civil Air Patrol.

Stuart Sharack [NEST '07] won the Civil Air Patrol Aerospace Educator of the Year Award.

Haia Spiegel [NEST '07] was the 2009 recipient of the "CREC Teach of the Year" award.

As an incentive to develop good note-taking skills, I have incorporated notes into quizzes and tests. All quizzes are unannounced, but, at the same time, they are open-note. Students who have a good set of notes find that quizzes are no problem. They serve the meaningful role of letting both the students and the teacher know where everyone is on the topics covered in the quizzes, allowing both students and teachers to modify the learning pattern, optimizing the results.

On tests, I allow students who have not missed more than two assignments (homework, lab reports, etc.) to prepare and use an index card of hand-written notes. The assignment requirement needed to get the index card improves the effort and study habits of the students. The index card of notes reinforces the note-taking skills while also helping the students improve their study habits. Merely going over the text and their notes can expend a large amount of time with minimal results. Spending the time reading over their notes, deciding what is important and writing those important points in an organized manner is a productive use of their time. [Even if such a card is not allowed in a course, creating it is a good way to study—another point I learned as an undergraduate.]

The skill of taking notes is important enough that it merits finding means of encouraging students to take it seriously. Therefore, in addition to the initiatives noted above, notes are sometimes collected and graded, either for extra credit or as a part of the regular grade. A clear message is given at the beginning of the year and is reinforced every now and then, helping the students develop this important component of their education. ❅

Chemistry is cursed with unsuitable ancient words and names that are understood by practitioners and confuse the uninitiated.

—Ronald Breslow

NEST—Birth of a New Activism

Ron Latanision

[This article appeared 20 years ago in the first issue of this newsletter.]

Last summer, the Materials Processing Center (MPC) at MIT decided to conduct an experiment: high school teachers were invited to campus to see how the basic science they teach forms the foundation for the research that scientists and engineers conduct to meet society's technological needs.

By all accounts, the experiment was a success. But then something truly remarkable occurred. The energetic teachers who attended 1989's inaugural program organized themselves into a federation, New England Science Teachers (NEST) with representatives from each state in New England.

These teachers share MIT's concern over the predicted shortfall of up to 700,000 scientists and engineers Just as disturbing is the predicted shortage of nearly 300,000 science and math teachers in secondary schools.

Last November, NEST met to establish an agenda for high school science (and engineering) education in New England. The organization now has several committees: two examples are the Elementary Resource/Mentor Committee that investigates ways to reach out to the elementary schools in each school district, and the Governmental Affairs Committee that advocates educational priorities to the executive and legislative branches in each state.

NEST will next meet on June 30th after this year's summer program. The Materials Processing Center invites all New England science and math teachers to become members of NEST. Please tell us of your interests, and we will ensure that you receive future mailings.

[Note: For the first two years, all members were from New England schools. When the membership expanded, the name of NEST was changed. Also, at first, the newsletter was not limited to NEST members.] ❅

2009 SEPT and the NEST Retreat

Dallas Russell [NEST '05]

In the early afternoon of Sunday, June 21, 2009, an eclectic array of educators assembled on the storied campus of MIT. They were in eager anticipation of the NEST experience that emphasizes excellence in education. They came from as far away as Norway, Germany and Argentina and as close as Boston and the greater New England area. There was a strong contingent from Florida and participants from California, the Pacific Northwest and a myriad of points in between. All were people of character and competence who were seeking to collaborate in order to cultivate excellence in the high schools and middle schools in their home districts.

After a few moments of social interaction around refreshments, founder/director Ron Latanision called the conference to order. He set the stage by detailing the rich history of SEPT and NEST and by laying out expectations—including the illustrious tradition of the anonymous hack. He yielded the floor to Haia Spiegel who delivered a powerful power point presentation that detailed how her high school students collaborated with middle and elementary school students and with Northup Aerospace and NASA on an extensive science project.

Haia's presentation, punctuated with photos and handouts, served as a sparkling example of the high quality of excellence in education that can be achieved by all of our learning communities and of the superlative collaboration possibilities with industry and government. It sparks imagination and strategies of how to apply the hallmarks of her work to an assortment of other individualized scenarios. It was the final presentation of day one and it left a mighty impression on the minds of the SEPT participants as they prepared for sleep and Monday, day two.

MIT graduate students led the first presentation on Monday in the Stata Center. They showed how they made chemistry "cool" for high school students. They set off a series of chemical experiments that clearly electrify and resonate with the high school persona. The approach was interactive, so many of the participants interjected their unique perspectives. The fluid, eloquent exchange of ideas was flawless.

The first presentation was a harbinger of things to come. Presenter after presenter brought cutting edge, electrifying ideas to the SEPT audience, who in turn injected the presentations with unique comments and intriguing questions. Many of the participants used their personal laptops to link up with related websites and bring additional insights to the fore.

The radiant ambiance of academic bliss reigned supreme when a few of the SEPT participants started acting up, acting negative....even rude! This brat-like behavior spread to other members of the SEPT audience like a wicked wave. Soon a significant part of the audience was singing "Math Sucks" (a song by Jimmy Buffet) and totally disrupting scholastic paradise.

Some were stunned, others considered "Security" options, but before action could be taken, the Florida contingent of SEPT participants came forward and explained the orchestrated misbehavior as their contribution to the illustrious legacy of the "hack"—NEST-MIT style. It was a spectacular success.

Rainy, gloomy weather permeated New England for the duration of the SEPT/ NEST conference, necessitating a change of venue for the outdoor activities. Jeannie Pakradooni advanced the idea of an indoor picnic, with a light jazz combo over the usual Boston Harbor cruise. Her idea was a sheer, serendipitous stroke of genius as the spirit of connection, camaraderie and esprit-de-corps took deep root in close quarters, over fine Southern Cuisine, ample beverage and an inspiring speech from MIT's basketball coach, Larry Anderson.

Among the SEPT participants was Walt Gibbons, a physics teacher from New Jersey who just happened to have graduated from MIT ("back in the day"). His son recently graduated from MIT and was a stand-out basketball player during his tenure. It turns out that he knew personally Coach Anderson and invited him to join us for the evening. The coach was asked to make some impromptu comments to our group and he accepted this invitation without hesitation.

His remarks centered on holding yourself to a higher standard of consistent hard work (so high that others without your passion are unwilling or unable to match your effort) and on being cognizant, appreciative and even generous with the blessings given to you. His personal legacy spoke volumes as MIT basketball has soared from less than mediocre to perennial contenders for the conference championship under his auspices. His hometown in Mississippi is so proud of him that they practically throw a parade when they know that he is coming for a visit. He expressed sincere gratitude for their sentiments and for his fortuitous circumstances. In all of this there are parallels to us in more formal education. It is up to us to see them, determine how they relate to our own individual circumstance and apply them in our particular scenarios.

All of the speakers at the 2009 SEPT/NEST were superb. Some had *zero* lead time and no props, like the basketball coach, while others had plenty of lead time and a plethora of props, like the McNamara Workshop instructors. Even so, all were superb. An instructor that goes by the moniker "The Blue Dragon" displayed an eclectic array of lessons designed to spark classroom excitement. For instance, he created a "pop-gun" from a "spud" & a narrow pipe that was capable of sending a piece of potato half way across the classroom. High school students absolutely love stuff like that.

Some of the secrets of Pascal's Triangle were unraveled and explored in a separate workshop led by Kathy Segale. Patterns, sequences, applications to nature and more were examined. The instructor delineated patterns, within patterns, within patterns and brought a lot of props in order to maintain a high level of clarity to the concept of each pattern. Exposing the wonders of Pascal's Triangle to students in a manner similar to the style of this McNamara Workshop would yield excellent results.

Joe Scheller led a discussion that focused on concrete things that can be done right here and now to advance the cause of excellence in education. The entire NEST group participated in this evening event. Immediate application was a focal point and the rapid-fire replies were myriad and non-stop. It became clear that the issues facing quality education in America are very similar to those in Germany, Norway and Argentina. A bit of light and a fair amount of heat was generated by the sometimes-fiery discussion. Time will tell if any of the ideas manifested gain traction and prove to be solutions to the quality education quandary.

The Delta Design Project was one of the most intense experiences of the week. The group was arranged in teams of four: project manager, structural engineer, thermal engineer and architect. Each position had a specific set of sophisticated, detailed instructions and responsibilities. Each team member had to learn his or her own position, trust others to do likewise and then collaborate with one other to create a sound edifice on a fictitious planet, using outlandish weights and measures.

It was a "Hoot and a Holler" and it stressed some members to the breaking point—but not over it! In the end, the project experience was a colossal success as team members strove together furiously to ferret out all of the critical constraints and most of the beneficial parameters. The collaborative process, (the HOW) was the true GOAL, trumping the stated objective (the WHAT) of building the "Best" edifice.

The Awards Dinner of the final day of the conference and the after breakfast discussion of the final morning had a common theme; "Secure the NEST/SEPT Program @ MIT in perpetuity". In its current state, it is subject to the whims and caprice of circumstance. In tough economic times, donors and sponsors drastically reduce the level of their support. Even though the program has somehow pulled through each year, a more firm foundation is in order.

According to some reliable sources, an endowment of two million dollars or so should do the trick of perpetually financing the NEST/SEPT program at MIT. Generating this sum in the current difficult economy may prove to be quite a challenge, but perhaps collectively we are up to the challenge. We may have to think WAY outside of the box, but perhaps our experience with the traditional NEST "hack" and the Delta Design Project prepares us to think just like that!

Realistic Levels

[The following excerpt is from an article by W. James Popham that appeared in *Phi Delta Kappan* in April 2009.]

When human beings are asked to do what they know is impossible to do, they typically tend to give up or, perhaps, to look for ways to dodge such unrealistic demands. In education, some of these "gaming" ploys end up causing great educational harm to students. For instance, when teachers avoid teaching any content they think won't be tested, students are curricularly short-changed. Similarly, when teachers require students to engage in days of test-preparation drudgery, many of these students will learn to detest school. Such costs are too high.

Recommended Reading

[The following articles are highly recommended to be read, by both those reading this newsletter and also appropriate students.]

Bloom, Paul; In Science We Trust; *Natural History*; May 2009; pp. 16-20.

Butler, Louise; Head of the Class; *Mensa Bulletin*; August 2009; pp. 15-19.

Editorial, A Theory for Everyone; *Scientific American*; January 2009; p. 32.

Hall, Charles A., and John W. Day, Jr.; Revisiting the Limits to Growth after Peak Oil; *American Scientist*; May-June 2009; pp. 230-237.

Kolbert, Elizabeth; The Sixth Extinction?; *The New Yorker*; May 25, 2009; pp. 52-63.

Lederman, Leon M., & Malcom, Shirley M.; The Next Campaign; *Science*; March 6, 2009; p. 1265.

Quammen, David; Darwin's First Clues; *National Geographic*; February 2009; pp. 44-53.

Richardson, Joan; Looks Deceive; *Phi Delta Kappan*; June 2009; p. 698.

Singer, Maxine; Great Teachers for STEM; *Science*; August 28, 2009; p. 1047.

Starnes, Bobby Ann; On Experts, Blame, and Bold Ideas; *Phi Delta Kappan*; April 2009; pp. 608-609.

Starnes, Bobby Ann; These Kids Today; *Phi Delta Kappan*; June 2009; pp. 770-771.

Trefil, James, & O'Brien-Trefil, Wanda; The Science Students Need to Know; *Educational Leadership*; September 2009; pp. 28-33.

Zimmer, Carl; On the Origin of Sexual Reproduction; *Science*; June 5, 2009; pp. 1254-1256.

Science Education

[These excerpts are from "The Science Students Need to Know," an article in the September 2009 issue of *Educational Leadership* written by James Trefil and Wanda O'Brien-Trefil.]

…no student should be allowed to leave the educational system without acquiring the basic knowledge of the physical world incorporated in the great ideas. Only then will we be sure that students will be able to become fully participating members of our modern technological society. In the best of all possible worlds, we will turn out students who far exceed this minimal building code of knowledge. I would certainly expect more of university graduates, for example.

…I would argue that the quasi-mystical belief that students need to "know what scientists do" is misguided. There is, in fact, no magical scientific method, no silver bullet that, once mastered, will enable someone to easily acquire knowledge of new science. If you expect your students to understand molecular biology, you have to teach them molecular biology. You don't teach them physics and hope that this knowledge will help them understand stem cells. It won't.

Perfect Numbers

Avi Ornstein [NEST '89]

To start with a few quotes….

Nicomachus's *Arithmetica* (ca. 100 AD):

…the perfect are both easily counted and drawn up in a fitting order: for only one is found in the units, 6; and only one in the tens, 28; and a third in the depth of the hundreds, 496; as a fourth the one on the border of the thousands, that is, short of the ten thousands, 8128. It is their uniform attribute to end in 6 or 8, and they are invariably even.

St. Augustine (354-430):

Six is a number perfect in itself, and not because God created all things in six days; rather the inverse is true; God created all things in six days because the number is perfect. And it would remain perfect even if the work of the six days did not exist.

F.N. Cole (1861-1927) proved that M_{67} isn't prime, as noted by E.T. Bell in *Mathematics: Queen and Servant in Science*:

At the October, 1903, meeting in New York of the American Mathematical Society, Cole had a paper on the program with the modest title *On the Factorization of Large Numbers*. When the chairman called on him for his paper, Cole—who was always a man of very few words—walked to the board and, saying nothing, proceeded to chalk up the arithmetic for raising 2 to the sixty-seventh power. Then he carefully subtracted 1. Without a word he moved over to a clean space on the board and multiplied out, by longhand, 193,707,721 x 761,838,257,287. The two calculations agreed. Mersenne's conjecture—if such it was—vanished into the limbo of mathematical mythology. For the first and only time on record, an audience of the American Mathematical Society vigorously applauded the author of a paper delivered before it. Cole took his seat without having uttered a word. Nobody asked him a question.

Positive divisors are those integers that can be divided into a number an integral amount of times. Aliquot divisors are all positive divisors other than the number itself. Deficient numbers are numbers that are greater than the sum of the aliquot divisors. Abundant numbers are numbers that are less than the sum of their aliquot divisors. Perfect numbers are equal to the sum of their aliquot divisors.

Perfect numbers have been known for ages, as shown by the earlier quotes. Euclid listed a formula for even perfect numbers: $N = (2^{n-1})(2^n-1)$, where n is any positive integer greater than one that makes the second factor a prime number. Euler later proved that every even perfect number must be Euclidean. In reference to Nicomachus's quote, every Euclidean perfect number ends in 6 or 28 when the numbers are written in base 10 notation, though they do not alternately end in 6 and 8. Nor is there one for every number of digits.

Marin Mersenne (1588-1648) was a French friar who lived near Paris. As an amateur mathematician and scientist, he acted as a modified post office, transmitting the mathematical and scientific letters of his friends, who included Descartes, Fermat, Galileo and Pascal. In making reference to the numbers that fit the second factor for Euclidean perfect numbers (2^n-1) in his work entitled *Cogitata*, published in 1644, they became known as Mersenne numbers and are signified by the use of a capital M with the value of n as a subscript.

Mersenne correctly listed the first eight perfect numbers (6, 28, 496, 8128, 33550336, 8589869056, 137438691328 and 2305843008139952128) by giving the values of n as 2, 3, 5, 7, 13, 17, 19 and 31. He said that the values of n for the 9th, 10th and 11th were 67, 127 and 257. It turns out that 67 and 257 are incorrect and that he left out 61, 89 and 107 as values of n—but it took 303 years to check and correct Mersenne's statement!

There have been many conjectures as to how Mersenne arrived at his results, but no answer has yet been found. He must have discovered or had available some theorem not yet rediscovered. Some have supposed that Fermat communicated these results to him, but it seems unlikely by his record. (2^{257}-1 has 78 digits!)

The 9th number (n = 61) was found in the 1880's independently by both Pervusin and Seelhoff. The 10th (n = 89) was found in 1912 by both Powers and Cunningham, again independently. The 13th through the 17th were discovered in 1953 by Robinson, using a SWAC computer and an algorithm developed by Lucas in finding the 12th in 1876. It uses the series: 4; 14; 194; 37634;… $u_n = (u_{n-1})^2–2$. If and only if the (n-1)th term is exactly divisible by N, where $N = 2^n-1$, is N a prime. (For example, 31 divides into 37634, so 31 is a prime number.)

Mersenne had stated that all eternity would not suffice to tell if a 15- or 20-digit number is prime. In a few hours, Robinson's computer program had tested 42 numbers, the *smallest* of which had 80 digits! It took 13.5 minutes to determine that M_{1279} is a prime while a human might have taken 125 years! Today's computers leave SWAC in the dust. As of this writing, 47 perfect numbers were known. The largest of these has a total of 12978189 digits!

2^n-1 can be a prime only if n is a prime, but 2^n-1 may be composite when n is a prime. This definitely adds complications to identifying perfect numbers. However, there are also other interesting properties of this set of even perfect numbers. Here are two of them.

Perfect numbers are equal to the sum of 1 through the Mersenne number.

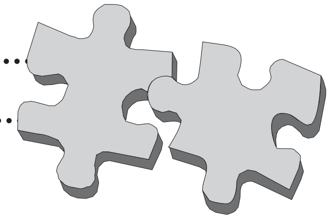
1 + 2 + 3 = 6
1 + 2 + 3 + 4 + 5 + 6 + 7 = 28
1 + 2 + 3 + … + 28 + 29 + 30 + 31 = 496

Except for the first perfect number, 6, if a = n-1, then the perfect number is always equal to the sum of the series of the cubes of the first $2^{a/2}$ consecutive odd numbers. That is:

n	a	$2^{a/2}$	N	cubes
3	2	2	28	$1^3 + 3^3 = 28$
5	4	4	496	$1^3 + 3^3 + 5^3 + 7^3 = 496$
7	6	8	8128	$1^3 + 3^3 + 5^3 + 7^3 + 9^3 + 11^3 + 13^3 + 15^3 = 8128$

No odd perfect numbers are known. While it has not been proven that none exist, several specific requirements have been proven. Here are a few of them:

- It must leave a remainder of 1 when divided by twelve and a remainder of 9 when divided by 36.
- It must have at least 9 distinct prime divisors.
- If not divisible by 3, it must have at least 9 distinct prime divisors; if not divisible by 21 (that is, 3 and 7), it has at least 11 such divisors; if not divisible by 15 (that is, 3



PUZZLE CORNER

#1) What is interesting about the following paragraph?

> Paying attention to occurring choices helps establish something oddly devious. Essentially, something other than how one normally observes basic arrangements really entices neurological effects. For openers, patiently assume sequences each affect final ideas.

#2) Why is there a dark spot in the center of a burning candle?

Solutions to the previous problems:

#1) If you reverse them, you get larger two-digit numbers, and if you then square the pairs, you get numbers that are similarly the reverse of one another.

$12 \rightarrow 21$ and $12^2 = 144$ and $21^2 = 441$
$13 \rightarrow 31$ and $13^2 = 169$ and $31^2 = 961$

#2) The pair is 33 and 99, since $33^2 = 1089$ and $99^2 = 9801$.

and 5), it has at least 14 such divisors; and if not divisible by 105 (that is, 3, 5 and 7), it has at least 27 such divisors. (In 2006, the number of distinct prime divisors if not divisible by 3 was expanded to 12.)

- If N has exactly R distinct prime divisors, the smallest will be less than R+1.
- In 2006, Goto and Ohno proved that the largest prime factor is greater than 10^8.
- In 1999 and 2000, Iannucci showed that the second largest prime factor is greater than 10000 and that the third largest is greater than 100.
- In 1957, Kanold showed that N must be greater than 10^{20}. It is now known that it must be greater than 10^{300}. ❆

Everyday Science

[This excerpt is from an article by Noah Feinstein in the June 2009 issue of *Phi Delta Kappan*.]

…The very messiness that our current education system sweeps under the rug is perhaps the most important thing for future citizens to understand. This is the understanding that must underlie a system of everyday science education, and this is the understanding that STS (Science, Technology and Society) research can provide.

STS research also confirms the fundamental underlying assumption of everyday science education: Science and technology play an increasingly important role in all aspects of our lives. We encounter them whether we choose to or not, and though they may not offer solutions to our problems, they are frequently part of both problem and solution.

The Great Ideas of Science

[This is excerpted from an article by James Trefil and Wanda O'Brien-Trefil in the September 2009 issue of *Educational Leadership*. In the article, each idea is explained.]

The following ideas form a superstructure for the edifice of science. If students have this framework in place, they will be scientifically literate.

- The universe is regular and predictable.
- Energy is conserved and always goes from useful to less useful forms.
- Electricity and magnetism are two aspects of the same force.
- All matter is made of atoms.
- Everything comes in discrete units, and you can't measure anything without changing it.
- Atoms are bound by electron glue.
- The way a material behaves depends on how its atoms are arranged.
- Nuclear energy comes from the conversion of mass.
- All matter is made of quarks and leptons.
- Stars live and die.
- The universe was born at a specific time in the past, and it has been expanding ever since.
- Every observer sees the same laws of nature in operation.
- The surface of the earth is constantly changing.
- The earth operates on many cycles.
- All living things are made from cells, the chemical factories of life.
- All life is based on the same genetic code.
- All forms of life evolved by natural selection.
- All life is connected. ❆

Houston, We Have an Experiment!

Donna Rand [NEST '00], Rose Sliva, Haia Spiegel [NEST '07] & Kirsten Tamborini [NEST '06]

Students in grades four through twelve, from three Capital Region Education Council schools in the Hartford region, gathered with high anticipation on February 26th, 2009, to watch a live video-feed sent from the Johnson Space Center in Houston, Texas. Their teachers had just stepped off a NASA aircraft in which they had experienced microgravity. This was an opportunity for the students to find out what happened during the 105 minute flight of a special 727 aircraft that performed a series of maneuvers to take their student experiment into a microgravity environment. The teachers communicated their excitement and experiences of microgravity and also answered many questions such as:

Did the experiment work?
What did it feel like to be 'weightless'?
Did you vomit?

The four teachers, Haia Spiegel from Greater Hartford Academy of Math and Science (GHAMAS), Kirsten Tamborini from Two Rivers Magnet Middle School and Donna Rand and Rose Sliva from East Hartford Glastonbury Elementary Magnet School, arrived in Houston a week before the flight. In preparation for the flight, the teachers got a crash course on the various aspects of the effects of microgravity on their ears, body and mind. They were also exposed to an experience of a loss of cabin pressure and oxygen in a high altitude chamber that simulated the experience of breathing at 25,000 ft. above sea level.

While preparing the student experiment for the test readiness review by 15 NASA personnel, the teachers noticed that one part of the experiment was cracked due to a stress fracture. This was a real-life engineering problem that was repaired due to the students' accurate preparations of CAD drawings. When asked what he learned from the experience, Cody Harris (a junior at GHAMAS) replied, "I learned how to work on a tight timeline and solve unexpected mechanical problems, sometimes from one part of the country to another."

In order to experience microgravity, the plane completed sixteen parabolas on its way out over the Gulf of Mexico and sixteen parabolas back to Ellington Field in Houston. One parabola mimicked the lunar gravitational pull and another mimicked a Martian gravitational pull. Two teachers accompanied the experiment on each of two consecutive days. In the true name of science, the second flight allowed for tweaking and adjusting the experiment to achieve maximum results.

"Microgravity was indescribable," said Tamborini. "It felt like swimming in water, but with no resistance."

"I can now relate to seeing astronauts floating in the International Space Station," said Rand. "Pushing lightly on one wall sent me up to the ceiling over someone else's experiment!"

"It felt like a flying dream," said Spiegel.

While enjoying the experience of microgravity, the teachers' main focus was on their experiment. The theory behind the experiment was to assert that spheres pack most efficiently by forming hexagonal arrangements. Packing material in an efficient manner is important to NASA as they need to maximize any available space when they take anything to space. It may also affect the construction of materials in space. During the flight, the spheres in the experiment did not behave exactly as the students predicted. When conducting the experiment, the teachers viewed the movement of the spheres.

"We pulled the plunger and, instead of rising quickly, the spheres rose very slowly," said Rand. "The spheres went slowly in different directions and even clumped together. They all settled back down abruptly as soon as we left microgravity." In hypergravity there was more of a vibration than a movement. GHAMAS high school students designed a computer system that is still evaluating the packing efficiency of the spheres in microgravity as compared to hyper-gravity and Earth's gravity.

The teachers on the microgravity team were treated to a tour of NASA's Neutral Buoyancy Laboratories (NBL) where many astronauts have prepared for space missions. (For every one hour in space, astronauts spend ten hours in the water.) The team visited mission control facilities for the International Space Station, the Shuttle and the historic Apollo center of operations.

The NASA project broke physical boundaries between schools with the use of technology and allowed an open line of communication between students of very different ages. Collaboration among three schools forced the teachers to apply new technologies such as computer cameras and distant learning facilities. The four teachers found it extraordinary how effective this project was in integrating real-life problem solving and critical thinking into the curriculum. The collaboration between the teachers continued after they returned from Houston. They worked together to promote science and STEM exploration through the excitement of the microgravity flight in several venues, including presentations to students at all three schools, at several schools and organizations in the greater Hartford area, at family nights hosted for school and local communities, to a state-wide audience at the New England Air and Space Museum and on local television.

Mixing high school students with elementary and middle school allowed A.J. Singh, a junior at GHAMAS, to remember the kind of knowledge he had when he was younger. "I was surprised at how much I learned and matured since 8th grade." Another high school student said that he learned to allocate assignments to others and communicate ideas more clearly. The younger students, on the other hand, looked to the high school students as role models. They were eager to discuss their ideas about the project design and learned a lot from watching the older students apply technology and math skills to solve problems.

The teachers see the process of problem solving and application of skills to a real problem as the important factor, much more important than the results themselves. "It was a fabulous experience for us," said Sliva, "but it is all about the kids. Hopefully, we learned as much from them as they learned from us."

"It was fabulous to see the progression of the project from paper drawings into design and then actually on the microgravity plane," said Brenda Lisitano, a GHAMAS senior. It was obvious that the students felt that they participated in a real event that may assist NASA in further space exploration.

In the future, Taylor Wrobel, a senior at GHAMAS, "would like to see how ionic, covalent and hydrogen bonds affect the molecular alignment in microgravity."

Who knows, maybe this project will inspire Taylor, Brenda, AJ, Cody and other students to be the next generation of NASA inventors and explorers?

[Note: This article also appeared in the June 2009 CSTA Newsletter.]

Top (from left to right) Haia Spiege, Donna Rand, Rose Sliva and Kirsten Tamborinil pose in front of the aircraft.
Left Donna Rand has a message for her students.
Below Haia Spiegel experiences microgravity.

Continued from page 1 "An Interview with Sheila Tobias & Anne Baffert"

What do you feel are the most important issues regarding education that can be changed in a positive manner? Baffert pointed out that it is doing what NEST is doing. Teaming teachers with scientists influences the public in a positive way regarding the attitude toward science education. Even more urgent is the need to reverse the current movement toward testing as a means of assessment.

At first, student testing was used (a.k.a. No Child Left Behind) to assess schools. Only in the past two years has student testing been used to assess teachers (first in NYC, then in Washington, D.C. and now elsewhere). Tobias credits this shift in part to the influence of Thomas J. Kane and Eric A. Hanushek, economist/educators, who have introduced "productivity" as a measure of teachers' "value," a direct application of the "value-added" approach used in business. "Beware of Value Added Management (VAM)," says Tobias. It is a sure way to deprofessionalize teaching." Nevertheless, rewarding teachers for "productivity" based on student test performance is gaining ground with "Pay for Performance" and other state government endorsements. "Productivity will eventually substitute for certification, years of experience and judgment by a teacher's peers," she predicts.

Another downside of the new testing culture is the resulting resegregation of schools. In inner city and rural schools, a wide variety of distractive activities are being used to keep students engaged. These techniques, very much teacher-directed, appear to be working with varying degrees of success (as measured by end-of-school-year test scores).[1] However, such methods are directly at odds with what teachers aim for in standard schools—namely a quiet classroom, single-minded attention to the lesson at hand and, eventually, student self-management.

In their new publication, however, Tobias and Baffert do not discuss pedagogy except in reference to how teachers are losing control over their choice of how to teach a particular lesson. Instead, they focus mainly on teacher retention in the face of the deprofessionalization of teachers' work lives. This is in the even larger context of what they see as a "war" between those who would undo public education and those who would defend it

To the extent that Teach for America and charter schools are permitted to circumvent teacher certification (and teacher unions), Baffert advises teachers to take an active role in deciding how they are certified and how they are assessed. This is especially urgent for science teachers. (Science is not yet part of the NCLB regime, but it will be.)

First, however, classroom teachers have to take back control. This may involve competing for administrative positions, most especially at the district level.

When asked what NEST members might do, Tobias and Baffert advise us to be where the power is in decision-making roles, including running for school boards. There is a need for us to apply our leadership abilities, even if we hate leaving the classrooms. Neither Tobias nor Baffert endorse one single type of pedagogy or a particular method of certification. Instead, they want to stir the pot!

1 – Jay Matthews; *Work Hard, Be Nice: How Two Inspired Teachers Created the Most Promising Schools in America*; Algonquin; UNC Press; 2009.

[Refer to *Information Exchange* on page 3 to learn how you can download their book.] ❅

Continued from page 1 "Co-Chair Report"

inside. Curiosity had gotten the best of me when I sliced the envelope open and read its contents. I let out a jubilant scream. I was, needless to say, quite exuberant and, as I stood in the kitchen jumping up and down like a wide-eyed young scientist, tears began to stream down my face. I had always longed to go to MIT someday. This was my chance. I attended in 2003 and am so grateful to the MIT Club of South Texas for providing the opportunity. I also attended several NEST retreats thereafter. I was so appreciative for the knowledge and to drink from the fire hose that I felt it was important to give back in some way. So, when I learned that I had been nominated and elected to serve as an Executive Board Representative and later as Co-Chair, I was extremely honored and humbled at the same time.

MIT has provided an additional opportunity for me to learn about science, technology, engineering and mathematics (STEM) in such a way that has enabled me to make a difference in my students', parents' and peer's academic lives. When you reflect upon who will make decisions about the world's future, I know that the leadership skills will come from many talented individuals with a science background. The Science and Engineering Program for Teachers (SEPT) provided me with an outstanding foundation in regard to STEM problem-solving with global impact. To be part of the fifty educators from around the world, assembled in one room for one week, and to have a passion for science was truly astounding.

"This immersion in science and engineering has made a profoundly positive impact on how I will teach my young, talented students. This week has opened my eyes in how to be part of a valuable team that helps to prepare young students for their future."

Andra L. Zoller, SEPT 2003, Texas

The Network of Educators in Science and Technology (NEST) annual retreats have allowed me to continue my quest to bring the best of the best STEM information and techniques to my elementary-age students in an applicable way that they can understand. MIT's willingness to continually share and present state-of-the art and frontiers in science and engineering research has helped educators across the globe to emphasize business-world preparedness and the importance of our dependence on a technically literate society. In other words, the STEM knowledge that I teach my students in kindergarten through the fifth grade will prepare them for their future. Throughout this process, my visionary approach and experience as Elementary Science Teacher of the Year in the state of Texas has aided my students' academic preparedness through at least grade sixteen and quite possibly beyond.

In conclusion, I would like to say a sincere Happy Birthday, STEM and NEST! I would also like to whole-heartedly thank the SEPT and NEST pioneers, such as Professor Ronald M. Latanision, and his tenacity, purpose, vision and collaboration for two outstanding programs that have helped many educators serve as STEM liaisons and ambassadors to the education, university and business worlds. Finally, kudos to MIT for its continued support, respect and understanding of the importance in "Building STEM Bridges through Global Impact" for the world's future generations to come. ❅

Mandated Curriculum

Avi Ornstein [NEST '89]

The mind is not a vessel to be filled, but a fire to be kindled.
—Plutarch

Think back to the good teachers you had—the ones you truly appreciated and are therefore easy to remember. Do you remember them for the facts you learned in those classes or the grades you got on the tests? Probably not. It is far more likely that you remember them for sparking your interest in the subject, for the way they directed the class and presented the material and/or the way they showed personal concern for you and your future.

Despite images presented by the media and government, the purpose of education is *not* to memorize facts and to be able to do well on specific tests. The true purpose of education is to learn how to learn. The idea is that you need to be able to find facts and then understand and use them. You need to learn how to communicate clearly, so you understand others and they understand you. You need to be able to put ideas together so that they make sense, and you likewise need to be able to recognize when things do not make sense.

I find that good, meaningful teaching is an art, not a science. This is especially true regarding teaching science. How one teaches can often be more important than what one teaches. In science education, an extensive quantity of new and continuously changing ideas must be presented. In addition, the same ideas are explained with more complexity as students mature. It is important to recognize that science itself is an organized way of thinking. It is a way of looking at questions and trying to decide whether the perceived answer is true, based on actual observations.

Those who choose to become scientists do not do so because of the stated *facts*. They do so because of their curiosity and the fascination in how different things all relate to one another. That is why science education should be hands-on, doing actual experimentation and observation. It should also be inquiry-based, having students reason out answers and explain what they observe and measure.

Increasing pressure is being directed toward teachers regarding the curriculum that should be taught in the classroom. There are positive and negative aspects to this topic. When students earn credit in a particular course, it implies they are prepared to proceed to certain higher level courses. It is therefore totally reasonable to define what should be included in the curriculum of a particular course. However, to enable teachers to make the learning experience meaningful and worthwhile, the curriculum should not tell the teacher how to teach, nor should there be a set of daily, regimented lessons.

In *Science Teaching as a Profession: Why It Isn't as It Could Be*, Sheila Tobias and Anne Baffert note how "teachers are starting to lose control over what and how they teach and how they are assessed." There is a need to be able to add relevant material when appropriate and to use a system that calls upon a teacher's strengths while also meeting the needs and abilities of the students in the class.

It is also important to recognize that teaching is very different from coaching a team. You can evaluate a coach by the score a team earns. In the classroom, the students are not recruited. Teachers cannot cull the enrollment, as they have to teach all of the students who walk in, whether they are or are not interested in the subject. If teachers are not given the freedom to use their experience, personality and individual skills to catch their students' interests, it is unreasonable to hold them responsible for the results.

As Tobias and Baffert stated, "When teaching truly becomes a respected profession, schools will be able to attract many more academically qualified candidates and be able to retain experienced teachers as well." ❅

Real Science vs. Paranormal

[These excerpts are from an article by Anne C. Lewis in the June 2009 issue of *Phi Delta Kappan*.]

Evolution isn't the only thing that brings out false as well as fabulous associations in students' minds. The same occurs with other areas of science, especially if they're theoretical or cutting edge: Real-world science goings-on incur student doubt, while their faith in the fringe and paranormal aspects of science remain boundless….

…To achieve a reasonable grasp of a scientific concept, some depth of understanding—education—is in order. Thus, the *idea* of the sheer diversity of life on Earth is startling, but a discussion of the mechanisms and conditions which made that life possible in the first place involves an understanding of atomic bonding, thermodynamics, and gas exchange across the cell membrane. Most of these processes can't be *seen* in any direct way….However, these processes are measurable, but measurement involves numbers and instrumentation and time and...well, you get the picture. Science is *hard*.

In contrast to mainstream science, paranormal phenomena do have the effect of "blowing things up" because they offer big, grand, gorgeous images that even the uninitiated can grasp and thrill to at first blush. It makes little difference if one has never seen Bigfoot, an alien, or a human clone. There are those who claim they have, and many, many others are eager to vouch for their existence by proxy.

Rethinking First-Year Biology Courses

[This excerpt is the opening paragraph from an article by Jeffrey Mervis that appeared in *Science* on July 31, 2009.]

Introductory biology courses are often the last academic exposure nonscience majors at U.S. colleges have to science. Unfortunately, say science educators, the courses too often leave a bad taste in the mouths of students who spend more time in lectures than on experimental learning and in regurgitating facts rather than understanding the concepts behind them. As voters, those graduates apply their misconceptions of science to shape national policies on everything from evolution to stem cell research. So improving introductory biology is seen as a critical step toward raising the nation's scientific literacy. ❅

Continued from page 1 "Those Who Can't Do, Teach"

setting and in industry, I have worked hypothesizing about and testing the role of various cells in autoimmune disease for my graduate thesis and I have investigated hypothetical energies involved in different combinations of materials. When I walked into a Maine high school science classroom in 1980, the questioning, hypothesizing, experimenting and analyzing did not end. If it had, I probably would have stopped teaching years ago. I am passionate about science—all aspects of science. I love doing it and sharing it with my students and my colleagues. As Schwartzkroin says, "One of the most noticeable features of successful scientists is their enthusiasm for the question at hand."

On the same visit to MIT that I purchased Schwartzkroin's book, I discovered another interesting and somewhat provocative text at the Hayden Library: *The Cambridge Handbook of the Learning Sciences*, edited by R. Keith Sawyer. It includes thirty-four essays by individuals at universities and industries who are experts on cognition, creativity, the nature of knowledge, artificial intelligence, learning environments and collaborative learning. It ends with a commentary by Seymour Papert in which he argues with his own previous theories of teaching and learning. All of these individuals exert a great deal of effort to determine who (learners and teachers) are doing what (teaching and learning) and how they are doing it. The more than 600 page text is full of information.

Reading their research, I was struck by how a classroom teacher like me is doing scientific research in most of these learning areas on a daily basis. Both Schwartzkroin and several authors in Sawyer's text talk about professionals, one referring to scientists and the other learners. My conclusion is that scientists are professional learners. Scientists and teachers are constantly questioning. What do I need to know? What shall I try? What happened? Why did it happen? What next? Furthermore, science teachers are professional science learners.

Scientists do science on the foundation of knowledge attained previously by other scientists. Schwartzkroin reveals the secrets of success in science—among them is "read the literature" and "respect the hierarchy." Knowledgeable and successful science teachers are not born as experts. Every teacher can recall one or more individuals who shared their expertise by modeling or mentoring. Mr. Jones, my high school math teacher, and Miss Mowry, my college religion teacher, demonstrated the skills of patient, thorough research and discourse that has been critical to my doing science and teaching. Professor Gilbert's clear visual explanations and Professor Young's confusing writings on the chalkboard gave me insight into immunology and biochemistry as well as demonstrating how to or not to present the information visually. Over the years, many colleagues have guided me to become increasingly effective as we shared techniques and literature.

Schwartzkroin explains how to think like a scientist—how to question, hypothesize, test them and generate results. As a researcher and a teacher, I am still questioning, still reading, still listening to experts. The Network of Educators of Science and Technology at MIT and the National Science Teacher's Association are critical resources for me as a scientist and teacher.

I formulate hypotheses and design experiments. The classroom and laboratory at school provide the environment. For example, if I permit my students to write topic summaries during class time, then more students will have more knowledge of the science and I will be able to assess that knowledge. To test this hypothesis, I decide what measurement I will use and how I will determine statistical significance of the results.

I test the hypothesis, do the experiment, gather the data, analyze the results and determine whether the technique is or is not effective within parameters I have set. Often I use the null hypothesis method to determine if the learning technique should be used again as is, modified or discarded. Schwartzkroin suggests caution and care in interpreting results. I concur with his suggestion.

Five chapters in the Cambridge Handbook of the Learning Science focus on methods of assessing learning. As a scientist, I try to isolate variables and eliminate errors but, as a scientist I know that is not always possible. It is apparent that the authors of those chapters see the limitations inherent in enabling and assessing learning, noting "Experimentalism rests on ideal conditions." It is apparent that specificity in the testing and analysis of learning will determine the degree of success in the scientific evaluation of teaching and learning. Complex systems within organisms in the lab, chemicals in a test tube or students in a classroom color the degree to which variables can and should be controlled.

A recognized aspect of teaching and learning is knowledge building. Scardamalia and Bereiter state, "Ours is a knowledge-creating civilization." As a research scientist, I am increasing the body of knowledge available to me and my colleagues, be it in the laboratory or the classroom. Schwartzkroin highlights one characteristic of scientists. Scientists are imaginative and, by training, they think within a given system but push and stretch the envelope to learn more. Successful teachers push the envelope. Not just the system of their students, but the envelope of their own teaching expertise and that of the teaching profession. The tenacity of a scientist in the laboratory devising new techniques to uncover the unknown is a mirror image of the stubbornness of a teacher trying and creating new ways to increase the learning of his or her students. Successful science teachers are imaginative. New methods and new insights are discovered by both types of scientific researchers. A truly successful scientist does not rest on his or her laurels, but finds new areas to explore. As technology develops, astronomers, geneticists, cell biologists, nuclear physicists and chemists are able to increase the body of knowledge. Technology is enabling teachers to devise new methods to increase the knowledge and thinking of their students. Information technology and gaming methodology are two of the most recent developments of some adventurous teachers. Many of the chapters in the Cambridge Handbook of the Learning Sciences describe the work of university and industry professionals collaborating with primary and secondary school teachers to expand the available body of knowledge. These new developments in science teaching are the knowledge we must know to be successful scientific teachers of today.

Hence, the key to increasing the body of knowledge in science and in the classroom is collaboration and communication. Successful scientists grow and share their knowledge with other scientists. It is the responsibility of a scientist to collaborate and communicate the knowledge gathered. Scientists talk to each other informally. They present their research and knowledge formally, both orally and in writing. Effective and successful teaching scientists share the hypotheses that have been shown "true" as well as those that have been "unproven." Scientists critique each other's work. Scientific teachers are open to the constructive criticism of their colleagues. Discourse enables creative analysis of the results of the scientific experiment, be it in the laboratory or in the classroom. I often tell the stories of scientific advances made over dinner in a Mexican restaurant (fullerene structure) or at a pub drinking a beer (particle tracing techniques). Likewise, the teachers' room can be the place of insightful discoveries.

Schwartzkroin expounds on the importance of writing well and presenting well. The professional scientist shares his or her expertise and new knowledge formally and informally. Journals and conferences are an important part of the professional life of the scientist and the scientist teacher. In the employment world of the research scientist, it is often said, "Publish or perish." It is here the scientific teacher can be remiss. Though there are volumes such as *The Cambridge Handbook of the Learning Sciences*, *The Science Teacher* and the *Newsletter of the Network of Educators of Science and Technology*, the teacher researcher is reluctant to publish. Modesty, lack of confidence, lack of know-how and time constraints all play a part in this reluctance. Yet, when teachers share their new knowledge or their expertise, it is lauded as an important event (evidenced by the enormously positive feedback to teachers who present at workshops). Schwartzkroin implores the young scientist, "*Self-marketing* is, for better or worse, a major part of the job of a young scientist." As a scientific teacher, I, like many, stop short of my work of increasing the body of knowledge of science by not regularly writing and sharing my *discoveries*. When I talk to my students about their scientific and technical writing, I ask them to imitate scientists in their activity. My students publish their work for their colleagues and mentors. Should publication of new teaching knowledge be a requirement of all teachers? Should novice teachers be mentored so they feel confident to create new techniques and to publish those techniques? I argue that, as professionals, we must be more aggressive in sharing our work. Publishing our classroom discoveries would certainly address the advice of Schwartzkroin to young would-be scientists. He asserts that science as a social enterprise is political. Publishing the scientifically achieved advances in our teaching would let the public be more aware of the professional nature of our work. While the public is very much attuned to the ethical nature of our scientific teaching profession (Schwartzkroin also instructs novice scientists), they do not always know the depth and breadth of the research and development teachers produce. If I am ever again assaulted by an individual ignorant of my profession, I can say, "Teachers do science as well as teach science."

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The deadline for publication
in the next issue is: **March 1**

Please send articles to:
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What Makes a Great Teacher?

[This is from an article by Erin Young that appeared in *Phi Delta Kappan* in February 2009.]

Participants at the 2009 summit said, a great teacher:

- Has the ability to be flexible, optimistic, self-reflective, progressive, and innovative;
- Must possess the ability to build relationships with students and teachers and have a passion for teaching;
- Excites a passion for learning in his or her students through skillful facilitation, using 21st-century tools;
- Goes beyond the classroom as a collaborator with colleagues;
- Wants to improve himself or herself by learning good instructional skills;
- Is someone who knows the curriculum and works well as part of a team;
- Builds relationships and facilitates lifelong learning;
- Collaborates with families, peers, and the community;
- Shows appreciation and enthusiasm for cultural differences;
- Inspires others to achieve their potential;
- Understands the complexity of the teaching and learning environment;
- Has consistently high expectations for all students;
- Recognizes and adapts when he or she isn't getting through to the students;
- Addresses the needs of the whole child;
- Uses assessment to inform instructional decision making; and
- Gives back through mentoring. ❆

Reading

[These excerpts are from an article by Lawrence Baines in the May 2009 issue of *Phi Delta Kappan*.]

Several large-scale studies confirm that students nationwide are eschewing reading for other pursuits. Less than one third of 13-year-olds read daily; the percentage of 17-year-olds who read nothing for pleasure has ballooned. In a span of 20 years, American students have transformed from being among the most to the least avid readers of literature in the world….

The average time an American teenager spends reading has shrunk every year since 1976 and now sits at an all-time low of six minutes and 30 seconds per day….

…Reading has come to represent an absurdly old-fashioned, even antisocial activity.

…In competition with electronic media, reading as a leisure activity is losing its appeal….

It is uncertain what a retreat from books will mean for the future of education and the intellectual capital of the nation. However, if current trends continue, we are about to find out.

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