NETWORK OF EDUCATORS IN SCIENCE & TECHNOLOGY

Working to Promote Science Literacy in association with the Massachusetts Institute of Technology

Volume 26, No. 1 Spring 2014

Contents

Co-Chair Report

Eric Klopfer

When is a sabbatical not a sabbatical? When you don't leave town. That is what my sabbatical has been like for the last half year. Somehow, I've turned out to be busier than during a "normal" year, though being around allowed me to be part of the NEST board meeting this winter.

My big sabbatical project is the creation of four new edX course modules (edX is the consortium that MIT co-founded with Harvard to create Massive Open Online Courses—MOOCs). The modules that we are creating for the fall are on the design and development of games, the design and development of educational technology and then, in the spring of the following year, we'll launch one on the design and development of educational games and one on implementation and evaluation of educational technologies. It has been an interesting new challenge with a lot of on-location video, interviews and online activities.

This work coincides with the launch of our version 1.0 of The Radix Endeavor—our massively multiplayer online roleplaying game for high school biology and mathematics. You can find it at radixendeavor.org. We already have thousands of people playing online and we're hoping to grow those numbers quite a bit over the spring semester.

As the spring rolls on, we'll be turning our attention to the 25th annual Science and Engineering Program for Teachers. This is quite a milestone and we'll be working hard on creating a great program for this summer. We also want to make the annual NEST event something that many of you will want to attend. I hope to see you there.

GW-MIT STEM Policy Institute

Day 1

The Institute began with an introduction to the current Capitol Hill political philosophies regarding education, followed by insight as to how to successfully interact within that political system.

Dean Feuer of the George Washington University introduced us to two competing philosophies. First, aggregate numbers of scientists and science educators have met all US science needs and will continue to do so in the future. Proponents may admit that although absolute numbers of scientists are met, there continue to be gaps across racial and socioeconomic groupings. Second, science-wise, the US economy is falling behind other nations

Continued on page 4

Inspiring Educators from Around the World

Rachael Manzer [NEST '13]

Over the course of our careers as teachers, we have all attended numerous professional development sessions. Have you ever come back from a workshop where you were so energized and inspired that you could not stop talking about it, even months after the workshop has occurred? That is the experience I had in June 2013 after participating in the MIT Science and Engineering Program for Teachers (SEPT).

I was one of 30 teachers from around the world that participated in the one week SEPT at MIT. After the first day, I clearly understood MIT's famous expression of "drinking from the fire hose." Every day professors from MIT taught us about the latest and greatest research in science, technology, engineering

Continued on page 19

Calendar of Events

April 25
Announcement of recipients of NEST Teacher of the Year Award and McNamara Workshop presenters

May 2
Student Award books and certificates are sent out to nominating teachers

June 22-June 28
Science and Engineering Program for Teachers at MIT

June 26
McNamara Workshops

June 27
Teacher Awards are presented at the 25th Anniversary Dinner

June 27-June 28
NEST June Retreat at MIT

September 1
Submission deadline for the fall newsletter

October
Deadline for NEST board member nominations by email and annual fee announcement

November
NEST board member election and annual membership fee collection

January
NEST Executive Meeting

Editorial

NEST has taken a new attribute. We are seeking an active role in enabling teachers to influence educational policy. This was set into formal motion by the STEM Policy Institute held at George Washington University last summer. This has been further advanced by hosting a workshop at the Spring 2014 National Science Teachers Association in Boston.

In addition, articles and presentations focused on policy issues will now be a regular component of this newsletter and will be marked by an asterisk (*) in the Table of Contents of each issue. As a starting point, a report on last year's STEM Policy Institute and a summary of actions we can each take to influence educational policy are included in this issue. The first was created by editing the reports drafted by members who attended the program. The second was written by Ron Latanision and me.

Legislators do not have a strong background in education or science. As of last summer, only two members of Congress had backgrounds in science and none had backgrounds in education. In communicating with legislators, we need to recognize that we are not "just teachers"—we are experts in the field of education, having direct experience of what is going on and what works. It is equally important that we take the role of being advisors rather than lobbyists. We are not delivering the message of organized groups, but instead are giving advice of what needs to be done.

Similarly, we need to recognize that legislators need to be presented with specific actions they can take, rather than talking from a philosophical perspective. Explaining the problems with excessive testing will not lead to meaningful action. Instead, we have to propose what legislative action should be introduced or supported. We then can back it with an explanation of why it makes a difference.

We also need to get to know our legislators' educational staffer. That individual may have no actual experience or background in the field, but that is the person who has to hear what we have to say. He or she will then be able to use that input in influencing the action taken by the legislator.

Read the policy articles, become informed—and then become involved.

School Is a Prison

[These excerpts are from an article of the same name by Peter Gray that appeared in the January 2014 issue of *Reader's Digest*.]

Schools as we know them today are a product of history, not research….

…The top-down, teach-and-test method, in which learning is motivated by a system of rewards and punishments rather than by curiosity or by any real desire to know, is well designed for indoctrination and obedience training but not much else. It's no wonder that many of the world's greatest entrepreneurs and innovators either left school early (like Thomas Edison) or said they hated school and learned despite it, not because of it like Albert Einstein).

Most students—whether A students, C students, or failing ones—have lost their zest for learning by the time they've reached middle school or high school….researchers have shown that, with each successive grade, students develop increasingly negative attitudes toward the subjects taught, especially math and science.

…Research has shown that people of all ages learn best when they are self-motivated, pursuing answers to questions that reflect their personal interests and achieving goals that they've set for themselves. Under such conditions, learning is usually joyful.

…The biggest, most enduring lesson of our system is that learning is work, to be avoided when possible.

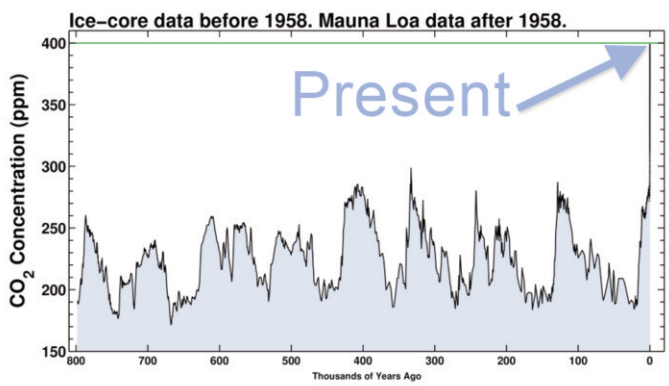
…three core aspects of human nature—curiosity, playfulness, and sociability—can combine beautifully to serve the purpose of education….

Worthwhile Websites

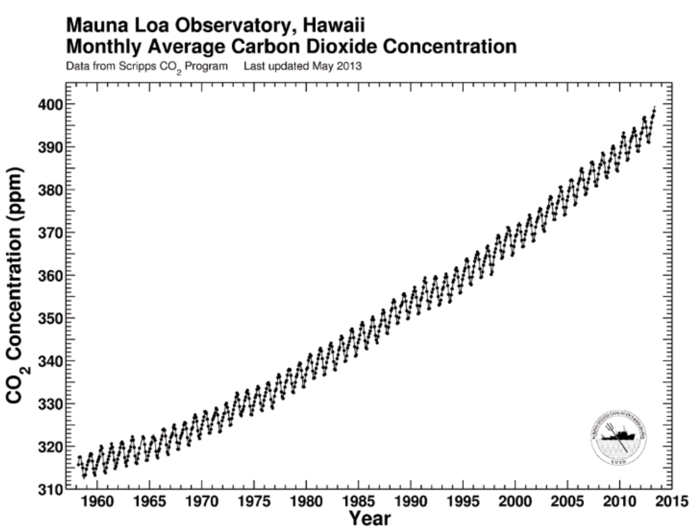
An interesting article on unreliable lab research:
www.economist.com/news/briefing/21588057-scientists-think-science-self-correcting-alarming-degree-it-not-trouble
A blog on excess educational data:
http://pdkintl.org/blogs/learning-on-the-edge/driven-by-data
The Inconvenient Truth behind Waiting for Superman:
http://vimeo.com/41994760
Nobel Laureate Carl Wieman’s view on science education:
http://thetartan.org/2014/2/2/scitech/scied
Positive article in the Washington Post:
www.washingtonpost.com/blogs/answer-sheet/wp/2014/02/22/you-think-you-know-what-teachers-do-right-wrong
Teresa Caracciolo
www.youtube.com/watch?v=xWlFazRq6K8&list=UURujkqhiAtkHHAXXMJ5AR4w

CO_2 Milestone

[This brief note is from the Fall 2013 issue of the “Society for Science & the Public Newsletter.”]



Atmospheric carbon dioxide levels recently hit 400 parts per million at Hawaii’s Mauna Loa Observatory. Ice cores show that today’s concentration far exceeds any in the last 800,000 years. The last time CO_2 passed 400 ppm was probably more than 3 million years ago, when temperatures were 3 to 4 degrees Celsius warmer than today.



Global Warming

[These excerpts are from an editorial report that appeared in the October 2013 issue of *Scientific American*.]

This month the Intergovernmental Panel on Climate Change (IPCC), the United Nations-affiliated body that serves as the world’s foremost authority on climate science, is scheduled to issue the first installment of its new climate assessment, six years in the making. The massive report, the panel’s fifth, is being released in four parts between now and October 2014. It is stuffed with science, woven together by more than 800 scientists. And it is already out-of-date.

Here are a few recent results that you won’t find in the new report: A study published last November found that Arctic permafrost is thawing much faster than we thought, an ominous development that could expel massive quantities of the greenhouse gas methane into the atmosphere, accelerating climate change. Ice sheets in Greenland and the Antarctic are also melting faster than anticipated, which could make the IPCC’s estimates for sea-level rise read like yesterday’s newspaper.

The IPCC’s report also won’t make use of the latest advances in the models used to predict climate change. In July, Kerry Emanuel of the Massachusetts Institute of Technology updated the computer models used by the IPCC with more fine-grained data about cyclones, revealing that these storms could increase in number, not just intensity, as the current report holds….

If the IPCC is to maintain its status as the world’s most relevant and respected summarizer of climate science, it must evolve. Knowledge moves fast. The rest of the world needs the IPCC to keep up.

> There is something fascinating about science. One gets such wholesome returns of conjecture out of such a trifling investment of fact.
>
> —Mark Twain
> *Life on the Mississippi*

Continued from page 1 "MIT-GWU Program in STEM Policy"

due to inadequate education of students. Proponents may believe that teachers and/or teacher education are the issues to be addressed. Quite simply, both the educational issues important to and the policies that will be supported by a Senator or Congressman are directly related to his/her position on the above spectrum.

Jim Jensen, a DC lobbyist, provided an introduction to the Congressional decision-making process and also a brief introduction to current politics regarding STEM education. For the most part, legislators support the idea of increased or improved STEM education. However, they do not have a strong STEM background, nor are they scientists or science teachers. Thus, their approach is to evaluate plans for action. Educators and scientists need to understand this because our traditional method of communication is data presentation to an audience who then make informed decisions for creative solutions. This method of communication is insufficient towards a Congressional audience whose focus really is choosing the best of the presented "decision options." This information needs to be shared with other educators throughout the U.S.

The first step in better communication between educators and Congressmen is research and knowledge, both of the audience and of current policy proposals. After that, for any proposal that educators support or design, two important factors are consensus and business community support, as these two factors weigh heavily in the Congressional decision-making process. In addition, for any plan or proposal, there has to be an objective, measurable way of assessing and presenting the outcomes (i.e., increases or improvements due to the plan's interventions). This allows Congressional assessment for continued funding and also allows for media coverage of education progression. The current standard for this is test scores. If we as educators feel such scores represent an inadequate measure for program success, what standard(s) do we wish to propose in its place?

Finally, the importance of teachers working at the local level and then up from there was introduced. This discussion was continued and expanded in the afternoon debriefing. An important understanding is that educational improvements are a process, and a continual one at that. This allows one to shift planning gears from crisis resolution to long-term planning (education vision).

In the afternoon, Martin Storksdeick, Director of the Board on Science Education at the National Research Council (NRC), addressed the group on the role of the National Academy of Sciences (NAS), which has the mission "to improve government decision making and public policy, increase public understanding, and promote the acquisition and dissemination of knowledge in matters involving science, engineering, technology, and health." The National Research Council's independent, expert reports and other scientific activities inform policies and actions that have the power to improve the lives of people in the U.S. and around the world.

One central purpose of the NRC is identifying voids so that others can fill them. Storksdeick provided an overview of the organizations within the NAS and also the process through which the organization creates a balanced panel of experts who meet and then publish a Consensus Report. There are connections between in-school and out-of-school learning, so our daily efforts in our individual science classrooms can create and sustain lifelong increases in (science) learning.

The afternoon session concluded with a debriefing session by Helen Malone, an Educational Researcher affiliated with Phi Delta Kappa (PDK). Questions she asked prompted and captured insights from the group for further discussion and actions. The day then ended with a GW-MIT STEM Policy Institute Networking Reception co-hosted by PDK. This provided an opportunity to meet and mingle with other local science professionals in an informal setting and discuss opportunities and challenges. It was informative and insightful.

Day 2

Managing meaningful change requires creativity, communication, collaboration and critical thinking. The recurring theme was the need for communities to come together to design and implement a program for STEM education.

Tuesday morning we went to Loudoun County, Virginia, where STEM programs have been implemented in the elementary, middle and high schools. To engage students, a topic must be delivered to students using an integrated STEM approach with opportunities for technology and career exploration. Application of knowledge in a meaningful way is the hallmark of a successful program. As Dr. Ed Hatrick, superintendent of schools, suggested, "Education is a reflection of the life around us." The Loudoun county model program is based on the region's socioeconomic investment. Aerospace, agribusiness, banking and finance, higher education, technology, real estate development, small business and telecommunications have located in this northern Virginia area as the result of significant economic development efforts by local and state government.

Their K-12 STEM program demonstrates a liaison between corporate America, regional business leaders, and the K-16 educational pipeline. This region of Virginia has successfully tied economic development with educational reform by creating mentorship and internship programs between elementary schools, middle schools, high schools, local community colleges and the business sector. The specifics of the program known as SySTEMic Solutions are laudable, but it is the multiyear, developmental and collaborative approach to designing and implementing the program that is impressive. The pride in the program is evident in how the Liberty Elementary School cites the four-year process on the STEM section of their website.

The members of the GW-MIT delegation exchanged ideas in small roundtable discussions with a diverse panel of officials representing the collaborative effort. All parties demonstrated their tightly intertwined passions for bringing the best to students and ensuring economic prosperity for a community. How the type of program implemented in Loudoun County translates to economically depressed areas is still on the table in Virginia and is perhaps a more difficult educational and economic policy to design and implement. Where the Loudon County program is influenced by the need to produce a technologically savvy workforce, a broader vision of a STEM savvy citizenry might be more to the point.

The American Association for the Advancement of Science (AAAS) was the site of the afternoon meetings. Again, the theme of managing change through creativity, communication and collaboration was apparent. Dr. Shirley Malcom, head of their Department of Education and Human Resources, spoke with us at length, first to introduce us to the advocacy mission and structure of the AAAS, and then to share her extensive experience in developing policy to implement change in science education and literacy. Dr. Malcom spoke about the development of meaningful educational standards. As a major player in the development of Project 2061, a long-term initiative of the AAAS to help all Americans become literate in science, mathematics and technology, Dr. Malcom explained how "conversation" among the stakeholders enabled the organization to uncover the important aspects of science literacy while developing a strong grassroots organization to implement project. While part of the afternoon entailed a lecture on efforts to develop meaningful assessment for STEM standards, Dr. Malcom strongly emphasized the difference between "valuing the measurement and measuring what is valued." This statement resonated with the GW-MIT delegation.

Day 3

The morning was used for NEST members to review STEM issues and to discuss how to meet with members of Congress. The members then went to Capitol Hill to meet with their legislators or their legislative assistants. The meetings lasted from ten minutes to nearly an hour and members were able to express their views and concerns regarding education and STEM issues, offering their legislators the perspective of experienced, concerned educators. The legislators or their aides subsequently offered some NEST members tours of the Capitol or Gallery Passes for the House and Senate. Most NEST members reported being pleased by the serious attention given by the aides to what was actually being said during meetings. NEST members reported discussing a variety of relevant topics during their meetings. In addition, members considered the next steps that should be taken to build upon these experiences.

In the afternoon, the members attended a presentation and panel discussion at the American Chemical Society (ACS). In addition to looking at broad views, specific programs ACS can offer to help teachers were presented. These included offers of ACS college scholarships, having ACS members work with classes as science coaches, and the existence of the ACS legislative action network. They also shared several hands-on activities that can be used directly in classroom.

Day 4

During the final morning, participants had the opportunity to attend a meeting of the President's Council of Advisors in Science and Technology (PCAST). This is an advisory group of the nation's leading scientists and engineers who directly advise the President and the Executive Office of the President. PCAST makes policy recommendations in the many areas where understanding of science, technology and innovation is key to strengthening our economy and forming policy that works for the American people. A panel of their British counterparts also participated in this meeting and the Chair of PCAST and Presidential Science Advisor, John Holdren, publicly noted the presence of our delegation at this meeting.

The two questions discussed on the agenda had several common ties to STEM education:

1. What do cities look like and how can cities adapt in the future?
2. What will math education look like in 2025?

In order to solve problems generated by a majority of the human population living in cities and improve the quality of life, science, technology and math can play a critical role. Devising new sensors and generating data, from such things as taxicab traffic to heat loss in buildings, can generate data for use in models to ultimately help analyze problems and help people make choices that effect many people.

Improvement in quality of life in cites or "Urbanomics" cannot be done by science, technology, engineering and math alone; it will also include the need for the integration of the following three areas: policy; design; and analysis of data. As one speaker said, "Different types of fields and skills need to come together to solve problems. We must plunder different tools from different disciplines."

The theme of integration of knowledge areas was reiterated in the next group of mathematicians who presented their ideas for mathematics education in 2025. They spoke of a math gateway that should motivate people to use math toward applications of problems. This will include social problems that involve policy makers, designers and scientists and mathematicians, as well as anthropologists and social scientists who will need to use mathematical models to solve problems ranging from societal to biological systems.

Our students are growing up in a world where integration and communication between all areas of science, technology, engineering and math come together with social science, policy and design to solve many problems confronting society today. Student success in math has been measured to benefit the UK through higher salaries and underpins the 21st century needs for society. New diverse teaching methods that use online course materials have been successful there. According to one team of scientists, the cost pressure of not getting our students to enjoy and continue in math fields is too big to ignore and we now have a "once in a lifetime opportunity to improve student success in math."

The week's final session was held back at the GW campus. Helen Malone compiled the thoughts, findings and ideas from dialogue and discussion during the week into some major themes. First of all, politicians and policy makers do not have STEM expertise, although generally STEM is accepted as important and the people working in these fields are appreciated. Therefore, this leaves us with some questions to ponder.

How do we foster STEM awareness in policy makers who do not understand the subject or science education or research showing how people learn science? In addition, how do we move away from fact/test learning? One idea put forth by the group was to look at school accreditation versus state or national testing.

Communication was also a common theme this week with the need for our STEM policy group to find a unified language. The group also needs to figure out how to change the narrative about what people think about science and its role in society, how to infuse STEM into politics, and how to create equity for all kids.

> Identical co-education can be easily tried....It is only necessary for those who wish to get it...to put their hands in their pockets, and produce a couple of millions. The offer of such a sum, conditioned upon the liberal education of women, might influence even a body as soulless as the corporation of Harvard College is sometimes represented to be.
>
> —Edward H. Clarke
> *Sex in Education* (1873)

Kudos

Teresa Caracciolo [NEST '02] was selected as Teacher of the Year for North port High School.

Dana Dunnan [NEST '89] was interviewed on a radio station regarding his two books, "Notes to a New Teacher" and "Chalkdust Memories."

Sharon McCue [NEST '95] was one of the coauthors of "Pond Power" which appeared in the February 2014 issue of *The Science Teacher*.

Pete McLaren [NEST '95] was quoted in an article in the March 2014 issue of *District Administration*.

Achieving Goals

Avi Ornstein [NEST '89]

January 1st is conventionally the time to set New Year's resolutions, but you actually can set new goals at any time. If the impetus helps at that time of year, all the better, but do not refrain from initiating positive change whenever the opportunity arises. In addition, when considering change, it is nice to set high goals, but it is important that either they are achievable or that you recognize that you will benefit by striving for them. Think of Don Quixote's message in *Man of La Mancha*. In "The Impossible Dream," he sets the goal "to reach the unreachable star" and "to follow that star." More importantly, when considering change, think of the following advice of Buddha. "What you are is what you have been. What you'll be is what you do now."

The most important factor in achieving any goal is the effort you put into that change. As Edison said, "Genius is 1% inspiration and 99% perspiration." What you get out of anything is directly dependent upon what you put into it. After four decades as an educator, my fundamental philosophy has come down to a simple statement posted in the front of my classroom. "If you're willing to work, you'll learn how to learn and you'll earn a good grade."

The specific facts taught in school are not what are important. The most valuable thing that formal education can offer is aiding you in learning how to learn. That is something that will be useful and applicable in whatever path you later follow. This skill enables you to meet whatever challenges face you later in life, making it possible to succeed in whatever path you choose to follow. However, the willingness to work, to put in the time and effort, is still a critical component.

In the most recent unit I taught in my chemistry classes, students had been given five worksheets to learn the rules of chemical nomenclature. In each case, the worksheet was started in class. Students then had to invest the time and energy to finish them outside of class. Those who completed those worksheets on their own did well on the unit test. Unfortunately, that is not true for those who did not finish the worksheets.

If you find that you are having trouble in any school class (or in life in general), you should follow the example of "The Little Engine That Could." Keep telling yourself "I think I can—I think I can—I think I can." The mental attitude affects the outcome. Also, recognize that "practice makes perfect" is not necessarily true. However, the advice shared with me by my five-year-old grandson is true—"Practice makes easy." The more practice you get in on anything you are learning makes the task and the results easier, which usually will lead to better results.

Following Directions

Avi Ornstein [NEST '89]

The concept of following directions should be simple and straightforward. One is told what to do, often including how to do it. You then just do as you are instructed. The result should be reasonably productive. Unfortunately, such is far from the case.

As an example, consider the directions that often accompany a purchased item. In the past, the directions were usually fairly clear and easy to follow. Nowadays, many such directions were originally written in another language and then poorly translated. Some are mere diagrams, with no actual directions. They often include errors or are open to erroneous interpretation. They often lead to a state of frustration.

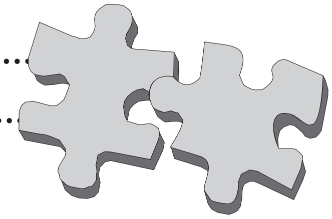
In the educational profession, the problem is often compounded. Students do not listen to the directions and often may want personal, individual assistance. When a teacher is helping another student, the 'excuse' that they do not know what to do leads to distraction and conversation, rather than attempting to figure out what needs to be done.

If directions are written, students often will skip over them, feeling that they are unimportant. They then complain about not knowing what they are supposed to do. As an example, I recently went over one problem, pointing out how the information needed to answer the question was included in the accompanying diagram. I stressed how they should always pay attention to graphs or diagrams that accompany a problem or worksheet, as they are placed there for a purpose. Later in the same class, the students were given a worksheet. At the top of the page, it stated: "Use the diagram below to answer the following questions."

As I walked around the room, students wanted me to tell them what to do. Others opened the text book, looking for answers to the questions. Still others were looking through their folders, wanting to know which of the handouts they had previously received had the necessary information. I said they could certainly get help from their teammates, but that I was only observing their effort at this stage, stressing that my goal was having them learn the skills needed to succeed on a broader scale.

I hinted that earlier in the class I had told them what they needed to do to find the answers. It was frustrating, but I allowed a sufficient period of time to elapse before going over the fact that they had to refer to the diagram. It was painful, but I hope that at least some of them gained a heightened awareness of the need to read directions. No matter what subject is being taught, this is a skill that is needed to succeed in life, and it is worth investing time on a repeated basis to drill this into our students.

PUZZLE CORNER



#1) Is friction good or bad?

#2) What is the shape of a falling raindrop?

Solutions to the previous problems:

#1) You will see a faint circle of the opposite color—that is, the color of a negative image of your original circle.

Cones perceive one of three colors—red, blue or green—the primary colors of light. (Look closely at a color TV screen and you will see that it consists of small dots of these three colors.) When you were staring at the circle, those cones that sensed that color were working steadily, while the others got a rest. When you removed the circle and looked at plain white paper, the rested cones responded more strongly, producing the after-image.

#2) Peripheral vision (that which is noted at the edge of the field of vision) is only perceived by rods. Unlike cones, these cells do not distinguish color.

The 3 R's

Avi Ornstein [NEST '89]

In education, "the 3 R's" classically refers to "reading, writing and 'rithmetic." While this may be appropriate in elementary school, I find it lacking in secondary education—or beyond. Almost ten years ago, I got into a discussion regarding this with a friend who similarly teaches high school science. We wound up deciding on a different set of "3 R's"—"responsibility, rigor and respect."

Responsibility applies to all involved individuals and at a variety of levels. Students are responsible to come to class prepared for learning, bringing whatever materials are required, and they need to be prepared to learn. This includes having an open mind and a positive attitude. If assigned work has a due date, they are responsible to meet that commitment. If outside factors create a problem, they need to let the teacher know why, and they should do this at the earliest possible time.

Teachers also share in the responsibility of the educational system. They must be certain that they are clear in class and in the assignments they give their students. They have a responsibility to find a way to answer appropriate, meaningful questions and they also need to have an open communication system with concerned students and parents. Similarly, they bear the responsibility to get work back to students in a timely manner, enabling the students to benefit from the feedback on the work they have done. Setting a good example also makes it easier to hold the students accountable for the work they are expected to do.

The responsibility extends to other domains. Parents need to create a comfortable home environment and encourage their children to work to their potential. They need to remember that more can be gained by taking a positive attitude than by focusing on threats and limitations. If this is done consistently from their children's youth, a major portion of the battle will have been won.

As Helen Caldicott said, "Teachers, I believe, are the most responsible and important members of society because their professional efforts affect the fate of the earth." However, to really work, the responsibility also extends further, encompassing the rest of the school staff, the administrators and the general community. What occurs outside of the home and classroom has a major impact on what occurs in the school. If we want our students—all of our students—to succeed, we as a society must take this seriously.

The second R is rigor. If the education does not challenge the students, it carries minimal value. We need to see our students moving forward, reaching new levels that were previously unattainable. Rigor makes the education harder, but it means there is a real reward for the time invested. Students may complain while they are doing the work, but they end up with a far better attitude in the end. Facing failure as they progress is necessary to really advance, but there is a necessity, at the same time, that the rigor is set at a level that is achievable by each student. If the trail is too rigorous, most will give up. Success is not measured by the grades that students earn, but by pushing themselves to their limit and actually advancing.

The final R is respect. Ralph Waldo Emerson aptly noted that "the secret of education lies in respecting the student." No one will willingly meet their responsibilities if they are not respected by those with whom they interact. Respect is therefore necessary in all directions. It is one of the responsibilities born be everyone. If it is lacking, it erodes at everything else. In 2007, Hillary Clinton said, "We have a teacher shortage because we have a respect shortage. I believe we have to start respecting educators again….Teachers are one of the most important determinants of the quality of a child's education…."

As a closing note, consider the advice of Ivan Illich:

> Education is not teaching; it is *learning*. Education is having the tools made available to you to learn in whatever way you wish, and it is being motivated to learn by having presented to you the wonderful world of possibilities.

What Remains at the End? Experiences of a German Participant of SEPT 2013

Paul Schlöder [NEST '13]

In June 2013 I had the pleasure to travel to the USA, being invited to attend the MIT Science and Engineering Program for Teachers (SEPT). Now, about nine months later, I'd like to take the opportunity to cast a look back to my stay, wondering what has come of it. I fondly remember all the colleagues I've met, the open and friendly exchanges and the relaxed atmosphere that invited fruitful and exciting discussions. It was most interesting to be able to have a look behind the scenes at one of the most distinguished universities in the US that allowed me to gain insights into the US science programs, insights I would never have been able to acquire otherwise. All modesty aside, it was a most extraordinary journey, not only geographically but also professionally.

Still, besides all the intellectual stimuli that were provided, comforts graciously offered and happily enjoyed, I'd like to review the impact the SEPT has on my work as a teacher, both with regard to teaching as well as relating to the professional exchange with my fellow colleagues in Germany. Of course, first comes to mind the wealth of material I have been able to gather. I have put it to further use, starting with debates among colleagues from different institutions, schools and universities alike, and also extending to press releases covering different aspects of science and education. The material allowed me to contribute and initiate professional discussions along different lines in regard to implementing new notions and ideas in the ongoing attempts to improve the teaching of science.

It is obvious that one of the most important aspects of teaching hinges on the motivational elements that help students to get involved in the learning process. Personally, it became very clear to me that possibilities for student involvement are rather abundant—if you know where to look. You need to search out the challenges modern society presents us with to find good starting points for students to work on. Overpopulation, industrial pollution, global warming and many other challenges are only to be faced successfully with science. And, thanks to a globalized media, we do not need to look long for stimulating examples: just remember the recent pictures from Beijing cloaked in industrial smog. And the only way to battle problems like that is to apply science; change comes from science, and change always works step by step. Your students do not learn physics as an end in itself; they learn it as way to bring about change.

Supporting student motivation by referring to current challenges is only the first step. This step has to be followed by making the specific challenge matter to the students. You thereby ensure that they develop an interest in acquiring an adequate skill set to look for a solution to the problem posed. One way to make a problem relevant to students is, as already pointed out, employing the media; another way is to let them experience science in a first-hand approach (e.g., by preparing experiments that are designed to impress the students).

At this point, I have to return briefly to my own experiences during the conference. I was very taken with the tremendous enthusiasm that everybody exhibited during every part of SEPT. It was an enthusiasm that was contagious; it seemed impossible not to be infected by it. One might think it naïve at first, but the truth is enthusiasm is one main ingredient in teaching science successfully. And enthusiasm can only be passed on to students if the teacher is enthusiastic about his subject.

In Germany, a teacher faces many restrictions: School leaving examinations are centralized; the science curricula are very specific; activities outside the curriculum are limited; and time is in short supply. With everything I have seen and experienced, I am sure that tackling problems, working on relevant issues and showing enthusiasm are essential for teaching science to students.

Thank you for letting me experience this first hand through this program.

Space-Time Perception

[This excerpt is from page 62 in a book by Rudolf v. B. Rucker entitled "Geometry, Relativity and the Fourth Dimension."]

A different trick for developing a space-time consciousness is described in Carlos Castaneda's book, *A Separate Reality*, an account of a Mexican Indian named Don Juan and his attempts to teach or show Castaneda a new way of interpreting reality. Certain sequences in the book give one the impression that Don Juan was actually trying to teach Castaneda to see in space-time. One of the exercises which Don Juan assigned was that Castaneda should start paying attention to sounds instead of sights. This may sound unimportant, but civilized man is in fact highly visually oriented. Most of our information (e.g., the printed word) comes to us through our eyes, as opposed, say, to a primitive hunter who depends to a much larger degree on his ears (e.g., tribal chants and sounds of animals). The interesting thing about our ears is that they perceive *time* structure instead of *space* structure. In other words, you can't hear what's going on in a room with a "glance" of your ears. It takes time to hear what's going on. Notice, for instance the way in which you hear a song on the radio. You do not hear it a note at a time. You hear chords, progressions, crescendos and so on. You perceive time-structure.

Viewing events in a historical perspective is another way to get closer to a space-time world view. That is, you can become more aware of yourself as a space-time structure if you keep in mind the way you were five minutes, five hours, five years ago. There are even moments of intense recollection when we actually seem to go back to the scene of a past event. The Argentinian write Jorge Luis Borges goes so far as to argue, in his paradoxically entitled essay, "A New Refutation of Time," that when you recreate a particular state of consciousness you actually return to the time when the original state of consciousness existed in you.

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.]

Frozen desserts have been around for a long time. Two millennia ago, Romans sent their slaves to the mountains to bring back blocks of ice. The ice was crushed and mixed with syrup and fruit. Marco Polo was served similar desserts in the court of Kublai Khan and Thomas Jefferson offered similar treats at Monticello two centuries ago.

However, the modern treat came about by accident in 1905 in Oakland, California. Frank Epperson happened to leave an unfinished fruit flavored soda outside with a wooden stick for stirring in a glass cup. Overnight, the temperature dropped below freezing and, in the morning, he found he was able to remove it by running hot water on the outside of the cup. Using the stick as a handle, he tasted the frozen treat and found that he liked it.

Epperson was only eleven at the time. He originally called it an Epsicle ice pop and his friends in school all liked it. He kept making it for them and, later, as an adult, he made it for his children. They reportedly called it "Pop's 'sicle" and the name stuck. It was introduced to the public at a fireman's ball in 1922 and a year later, eighteen years after his discovery, he began selling it at an amusement park in Alameda, California, and applied for a patent of his "frozen ice on a stick" under the trade name of Popsicle®.

Evaluation

Avi Ornstein [NEST '89]

For decades, questions were raised regarding evaluation of teachers that was based on administrative observations. Some feared that teachers could get either poor or favorable evaluations based or negative or positive relations with their administrator. This has led to attempts to resolve uniform rubrics for evaluating teachers which has now reached the point of desiring specific, quantitative scores that are based on data that focuses on issues other than the actual quality of the education offered to the students.

A new direction is to include student performance on standardized tests as a part of a teacher's evaluation. The question of whether the test is relevant to the course curriculum seems to be unimportant. Similarly, the variation of the students taking the test from year to year and the classes a teacher might be teaching are also ignored. This form of evaluation puts pressure on teachers to "teach to the test" rather than focusing on more important, fundamental issues in designing their curriculum. In addition, a 2013 PDK/Gallup poll of parents found that "58% oppose requiring that teacher evaluations include student scores on standardized tests."

Another recent misdirection is including parental involvement in the evaluation of teachers. This is outside of the classroom and lies beyond the teacher's domain. Interaction and communication with parents is an important factor in a good educational program. However, that is very different from holding the teacher responsible for the actions taken by their students' parents. In addition, teachers are expected to set specific goals for the level of parental involvement and then are evaluated on whether that goal is achieved. This leads teachers to set low goals so they can be achieved. As Michelangelo said, "The greatest danger for most of us is not that our aim is too high and we miss it, but that it is too low and we reach it."

Teachers should be encouraged to aim for the stars. Whether they achieve it is not as important as whether they are trying to do so. Good teachers motivate students by creating an environment where they are able to succeed and want to learn. Learning how to learn is far more important than merely learning how to spit back facts that can easily be looked up. To quote Ivan Illich, "Education is not teaching; it is *learning*. Education is having the tools made available to you to learn in whatever way you wish, and it is being motivated to learn by having presented to you the wonderful world of possibilities." Nonetheless, it is important to remember that whether the students do or do not succeed depends upon many forces that are beyond the teacher's control.

Students only spend about 12% of the year in school. Once they get beyond elementary school, they are in a single teacher's classroom only about 2% of the year. This should be kept in mind when evaluating a teacher. Making any advancement of getting students to want to learn and to think more clearly should be recognized as being miraculous in and of itself. A teacher that has a positive effect on some students without turning off many should be recognized as doing a good job. There is nothing wrong with sharing advice on how he or she can do better, but that should be based on direct observation rather than on the results of standardized tests or rather meaningless goals.

In a similar vein, it would be better if students could be evaluated and graded according to their effort, rather than on how they score on a series of tests. A weak student who is working at the level of his or her ability is far more impressive than a strong student who is simply sliding by. This view was expressed by Mahatma Gandhi, who said that "satisfaction lies in the effort, not in the attainment. Full effort is full victory."

Ex Libris XVIII: Notes on Some MIT Contributions to Aerospace

Stephen M. Rocketto [NEST '90]

For those of you who are new to NEST, this column originated when I was moved to produce a series of articles based upon books from my library. The column's focus would be on examining books, outside of the normal text book genre, that would bolster the background of teachers of science and technology. I was influenced by Prof. Philip Morrison whose *Scientific American* book review column I had followed for years. Meeting him at one of our convocations, I explained my idea and he encouraged my foray into the world of literary commentary. He also autographed my copy of his book, *Philip Morrison's Long Look at Literature* in which 100 of his reviews are published. From where I write this article, I can see it on one of my bookshelves.

Over the years, some of the reviews have discussed the writings of a single author such as the engineer and historian of engineering, Henry Petroski, or the beautifully illustrated books of David Macauley. I would choose what I considered an enlightening section from one of the four or five books under consideration and discuss it, trying to explain its application in some classroom. Common themes, such as meteorology, observatories (not necessarily astronomical) or plagues, were some past endeavors. The background stories and facts one learns add color to the often monotone textbook treatment of a subject and serves to foment a deeper interest in what is often very dry text book expositions. Students would perk up and ask questions when they heard about Isaac Newton's pursuit of counterfeiters, his voluminous writing in alchemy and his adherence to the Arian heresy.

My style has also been influenced by my brother, Hap Rocketto, an authority on the history of marksmanship, whose columns tend to start from some personal experience or an outrageous incident and then segue into the meat of his article. And so...

From my earliest days, I have been enthralled by aviation, perhaps because my uncle was a World War II B-17 navigator. Afflicted with childhood asthma and astigmatism, my "Babbitt-like" relatives, aunts and uncles told me that I could never be a pilot. My secondary choice, astronomy, was scoffed at since there was no commercial merit in a career gazing at the stars. I compromised and decided to become a navigator. In fact, the first aeronautical book I ever purchased, Lyon's *Practical Air Navigation*, resides to this day in a place of honor on my shelves. Alas, by the time I came of age, the noble profession of air navigator had been cast onto the scrap heap of history by technological advances. But Lyon's book was the start of a library of science, technology, history and works of literature on aviation numbering over 1,000 books.

By the way, never listen to distant button-down relatives. My parents believed in me and, as a result, I spent six of the best years of my life working for the Smithsonian Astrophysical Observatory during the height of the space age. I also earned my pilot's license before I had a driver's license and paid graduate school tuition by working as a charter and freight pilot. I never gave up that early love for aviation. Today, I fly search and rescue missions for the Civil Air Patrol (CAP) and meet my obligations to pass on what I have learned by working as an aerospace educator with CAP's cadet program and as a Boy Scout merit badge counselor.

I knew that MIT had a unique and rich history of contributions to aerospace. Well-known aviation personalities such as Jimmy Doolittle and Buzz Aldrin have ambled down the "Infinite Corridor." At least 30 former MIT students have served in the astronaut corps and MIT has been the maternity ward for a wide range of scientific and technological advances in aerospace.

This will not be a comprehensive review of what has transpired, but rather a commentary on some practitioners and technology that my random walk through the literature has uncovered. The primary source for material was my copy of William T. Trimble's *Jerome C. Hunsacker and the Rise of American Aeronautics*. I have also relied heavily on Michael H. Gorn's *The Universal Man*, Theodore von Kármán's *Life in Aeronautics* and Paul A. Hanle's *Bringing Aerodynamics to America*. The first two works are from the Smithsonian Institution Press and the last is from the MIT Press. But the bibliographies and notes in these three volumes revealed deeper possibilities and so I turned to the web in a hunt for further information.

There I found two valuable readings. The first was a biographical memoir of Hunsacker by Jack L. Kerrebrock. This is number 78 in a series published by the National Academy Press. The second was close to home: a condensation of a paper, *"A Century of Aerospace Education at MIT"* by Lauren Clark and Eric Feron, with additional material by William T.G. Litant appearing under the title: *"A Brief History of MIT Aerospace."* Both articles opened new historical paths for my trek.

Before MIT moved from Boston to the Cambridge campus, even before the Wright Brother's "First Flight," both faculty and students displayed interest in aeronautics. In 1896, graduate student Albert Wells used a primitive wind tunnel to study pressure variations on flat plates. In 1909, Professor Henry A. Morse visited Great Britain, Franc, and Germany in an effort to learn about European courses in aeronautics. An Aero Club formed in 1909 and tested a glider and a powered aircraft. One of the club members was Frank W. Caldwell.

Caldwell received a mechanical engineering degree from Tech in 1912. During World War I, he worked on propellers for the US Army Air Service at McCook Field in Dayton, Ohio. Later, Caldwell led the way in the development of adjustable pitch propellers. A propeller with a fixed pitch is akin to an automobile with only one gear. His early designs were ground adjustable so the aviator could only set it for either of two conditions, optimal climb or optimal cruise. Caldwell went on to develop mechanisms for setting the optimal pitch in flight. His engineering prowess culminated in the constant speed propeller that today is used on almost all but the simplest propeller-driven aircraft.

The central figure in the development of a program of studies in aeronautics at MIT was Jerome C. Hunsaker. The valedictorian of the U.S. Naval Academy class of 1908, he earned a master's degree in naval architecture at MIT in 1912. Assigned by the Navy at MIT's request to the Boston Navy Yard, Hunsacker was detailed to serve as a Tech instructor in naval architecture and develop courses in aeronautics. In the year preceding the outbreak of World War I, he traveled to Europe to inspect their aeronautical laboratories and meet with leaders in the field, such as Gustave Eiffel and Anthony Fokker. Upon his return, he designed and taught a graduate course called "Aeronautics for Naval Constructors," the first step in the development of an aeronautical engineering program at MIT.

If one might play on an epithet by Kant, theory without practice is empty and practice without theory is blind. While in Europe, he had visited the National Physical Laboratory in Great Britain and examined their wind tunnel. Hunsacker's new course in aeronautics would be accompanied by a wind tunnel for gathering empirical data. He enlisted the aid of his assistant, Edward Warner, and a student, Donald Douglas.

Warner, a native Bostonian, was a Harvard mathematics graduate who went on to MIT to major in mechanical engineering and minor in naval architecture. After his work on the wind tunnel, he was appointed Chief Physicist at the new National Advisory Committee for Aeronautics (NACA), the predecessor of the National Aeronautics and Space Administration (NASA) and built their first wind tunnel. Later, he served as the first Assistant Secretary of the Navy. The culmination of Warner's career was a twelve-year term leading the International Civil Aviation Organization developing the standards for a global commercial aviation system.

Brooklyn-born Douglas dropped out of the U.S. Naval Academy in 1912 to pursue his interests in aviation and then entered MIT, earning a bachelor of science in two years, probably by using some credits from Annapolis and attending extra sessions. After his work on the wind tunnel, Douglas left Tech and worked for the Connecticut Aircraft Company, which was building the first dirigible for the Navy. A year later, Douglas was employed as a civilian engineer with the Signal Corps Aviation Section. Moving on again, the peripatetic Douglas took a post with Martin Aircraft and was a designer of the MB-1, the first U.S.-produced bomber. 1920 found him in California, starting his first company. He then left that organization and formed the Douglas Aircraft Company which, among its many achievements, produced the Douglas World Cruiser, the first aircraft to circumnavigate the world, and the legendary DC-3, the aircraft that made commercial passenger service economically viable.

The opener of Hunsacker's sixty-year career was kick-starting MIT's aeronautical studies by producing two extraordinarily successful students who would make life-long contributions to aviation. He next designed the Curtis NC flying boats, the first aircraft type to cross the Atlantic Ocean, and led a team that designed the *U.S.S. Shenandoah*, the first helium-filled dirigible

Moving on, Hunsacker served as Chief of the Materials Division of the Naval Bureau of Aeronautics where he worked on the development of the technology needed to make ship-borne aircraft practical. In 1926, he joined the Bell Telephone Laboratories and was instrumental in the creation of a practical aviation communication system used to obtain weather reports. His next career move, in 1928, took him to the Goodyear-Zeppelin Corporation. While there, they produced the *U.S.S Akron* and the *U.S.S. Macon* for the Navy. These two airships, almost 800 feet long, were capable of launching and recovering airplanes while in flight.

In his first year at Goodyear, understanding the importance of good weather reporting, he urged MIT to create a meteorology department. MIT appointed Carl-Gustaf Rossby, a scion of the Norwegian "Bergen School" of forecasting, to head a program that pioneered upper air studies. Melding the theoretical with the practical, the new program also operated an instrumented aircraft for data collection out of what is now Logan Airport.

Hunsacker was back at MIT in 1935 as the head of the Department of Mechanical Engineering. He became head of the Department of Aeronautical Engineering when it was instituted in 1939 and administered both departments until 1947, when he asked to be relieved of duties in mechanical engineering so as to allow more time to devote to studies in the burgeoning fields of jet propulsion, supersonic flight and automated systems. He remained in the aeronautical engineering department until he retired from MIT in 1952.

He continued to serve as Chairman of the National Advisory Committee on Aeronautics, the predecessor of NASA, a post that he had assumed in 1941 and held until 1956, when he was succeeded by James H. Doolittle, another MIT graduate. While at NACA, which experienced phenomenal growth during the war, he rejuvenated the Langley facilities, established the High Speed Research Facility at Muroc Dry Lake in California and set up research units in Cleveland and Wallops Island, Virginia. Upon retirement he maintained an office in the Guggenheim Laboratory at MIT where he maintained contacts with colleagues and encouraged new generations of students.

Hunsacker's successor at NACA, James H. Doolittle, was none other than "Jimmy" Doolittle, USAF general and an MIT Ph.D. in Aeronautical Engineering. Doolittle made his name as a test and racing pilot during the 1920s and flew the first one-day transcontinental flight.

In 1922, the Army offered six appointments for serving officers to enroll at Tech in a master's degree program. Lt. Doolittle was an Army Air Corps test pilot at McCook Field where Capt. Edward Aldrin, father of the second man on the moon, "Buzz" Aldrin, persuaded Doolittle to apply for one of the appointments. At that time, Doolittle did not have a bachelor's degree, but he had attended the University of California and was eligible to receive a baccalaureate since he completed three years of study before enlisting when the United States entered World War I. Alas, he had never filed the documents to receive it. Aldrin and another colleague at McCook, unbeknownst to Doolittle, contacted the University and arranged for the granting of the degree, allowing Doolittle to matriculate at Tech in 1923.

Determined to graduate in two semesters, he enrolled in extra courses. At that time, the structural loads that an aircraft could take before failure were determined by loading weights on the grounded aircraft until something broke. Doolittle did not agree with this static approach and requested that he be allowed to base his thesis on dynamic data gathered from an aircraft in flight. The plan was approved and Doolittle conferred with his test pilot colleagues at McCook, acquiring an accelerometer from NACA and a Fokker PW-7 fighter from the Air Corps. In 100 hours of rolls, loops, chandelles and sharp pull-outs from dives, he studied the data and published his thesis, *Wing Loads as Determined by the Accelerometer*. The conclusions reached were critical to understanding the effects of accelerated flight on both the airframe and the pilot. The work validated much of the theory and discussed the short-term effects of accelerations on the physiology and mental processes of the pilot. The thesis became the core of his *NACA Report No. 203 - Accelerations in Flight*, which was translated into 12 languages and was highly praised by practitioners.

Doolittle had completed his master's, as planned, but he still had a year left on his military leave. He so enjoyed the academic atmosphere that he decided to work on a doctorate. His dissertation choice was to investigate how aircraft performance was affected by wind gradients, a disputed question among the members of the aviation fraternity. The initial step was consultation with a cadre of experienced aviators where he found disagreement amongst them about the effects of wind on flight. He then started to gather data in a flight program that utilized four different aircraft on 292 sorties, logging over 178 flying hours. His conclusions were that neither wind velocities not wind gradients affect an airplane in steady state flight. The dissertation draft was rejected by his advisors since it lacked enough mathematical calculations to support the conclusions. Doolittle gussied up the dissertation to satisfy the scholars who, on the MIT Seal, stand on the right, but he was unsatisfied because he wanted the report to be useful for the working man, the fellow who stands on the left of the MIT seal, and he believed that the mathematics was flummery.

Between earning his Tech Ph.D. and his appointment to NACA, Doolittle did much more. He pioneered the development of instrument flying technology and techniques. Moving to the private sector, Doolittle became an officer of Shell Petroleum where he promoted the commercial development of high-octane aviation fuels that allowed for the development of more powerful engines. At the commencement of World War II, he returned to the US Army Air Force and planned and commanded the first air raid on Tokyo. He led 16 twin engine B-25 Mitchells, launched from the deck of the *U.S.S. Hornet* and was awarded the Medal of Honor. By war's end, Doolittle commanded the Eighth Air Force, charged with the bombing of Axis forces in northern Europe.

Aldrin, who promoted Doolittle's entry into Tech, saw his son, "Buzz," turn down a full MIT scholarship to take the same from the U.S. Military Academy at West Point. Graduating with the Class of 1951 and taking his commission in the U.S. Air Force, the younger Aldrin found that flying USAF jet fighters could create a powerful intellectual thirst in a man and eventually came to Cambridge to "guzzle from the fire hose" of Tech academics, earning a Doctor of Science degree in Astronautics in 1963. The title of the dissertation was *Line-of-Sight Guidance Techniques for Manned Orbital Rendezvous*. This led to an assignment to the USAF Space Systems Division to work on the Gemini target project. Gemini was the NASA program developing a two-man spacecraft capable of rendezvous and docking with another vehicle in orbit. Aldrin applied for the astronaut corps and, on his second try, NASA accepted him for training.

Aldrin's primary responsibility was working on rendezvous techniques, a vital component of the planned Apollo missions to the moon, and he flew on *Gemini 12*, the last Gemini flight. *Gemini 12* successfully docked with an Agena target vehicle and Aldrin validated much of the theory about working outside a spacecraft with a record-setting extravehicular activity of five and a half hours. His last flight was aboard the *Apollo 11* moon lander.

The Gemini crew capsules, as well as the single man Mercury capsules, were built by McDonnell Aircraft in St. Louis. The company founder, James McDonnell, took his master's in aeronautical engineering from MIT in 1925. After working for a number of aircraft manufacturers, McDonnell founded his own firm in 1939. Starting small and doing a lot of sub-contracting of components for established plane manufacturers, McDonnell had a cyclical business history, since its primary source of customers was the military. However, its line of naval jet fighters, culminating in the classic F-4 Phantom II and the production of missiles and space capsules, provided sufficient capital to allow McDonnell to absorb Douglas Aircraft in 1967, which provided a line of commercial aircraft to buffer the cyclical military sales. Notably, both firms were started by Tech graduates. But that merger was not enough to provide long-term financial stability and, in 1997, another merger made Boeing the dominant partner.

Timber magnate William Boeing, a drop-out from Yale's Sheffield Scientific School, developed an interest in aviation and teamed up with his friend George Westervelt, U.S. Naval Academy class of 1901 and a 1908 MIT graduate in naval engineering. Disenchanted with a Glenn Martin designed aircraft which Boeing owned, they decided that they could build a better one and formed B&W, which soon became Pacific Aero Products. When the Navy transferred Westervelt to the east coast, the partnership was dissolved and Boeing Aircraft Corporation was born. Westervelt, however, took charge of the Naval Aircraft Factory at Philadelphia's Naval Ship Yard and remained there for six years. The Naval Aircraft Factory was a government-owned concern which not only did research, development and testing but also manufactured aircraft in competition with private industry!

Westervelt joined the Curtiss-Wright Corporation and rose to be Vice-president. One of his first assignments was to travel to the Far East and assist in the formation of the China National Aviation Corporation (CNAC). CNAC was backed by the Curtiss-Wright Corporation in the hope of profiting by fostering air travel in China and then selling CNAC airplanes and engines. Westervelt put CNAC on a solid footing and returned to the United States to resume his post with Curtiss-Wright.

But while Westervelt worked in China, he met a Chinese Tech graduate whom he had previously helped and he hired him as CNAC's Chief Engineer. Tsu Wong, a graduate of the Chinese naval academy, was sent to study at MIT in 1913 under Hunsacker and graduated in 1916.

Westervelt knew Wong in Cambridge and met him again when Wong went to Hammondsport, N.Y., to learn to fly under Glenn Curtiss. At that time, Bill Boeing needed an engineer for Pacific Aero Products and Westervelt recommended Wong, who was hired as the nascent Boeing Airplane Company's first engineer. Wong returned to China in 1918 and started China's first airplane factory.

Politically, Wong aligned with Chiang Kai-Shek's nationalist party, the *Koumintang*, and worked to develop aviation resources for the victorious battle against the Japanese Empire and the losing fight with Mao Zedong's Communists. After the war, Wong fled to Taiwan, where he chaired the Chinese Research Academy and held a professorship at Taiwan's Cheng-Kung University.

In 1915, while Tsu was in Cambridge, another Chinese national, Hou-Kon Chow, became the first person to earn an MIT Master of Science degree in Aeronautical Engineering with a thesis on aircraft stability.

In the 1930s, two Chinese cousins reported to MIT and earned graduate degrees. Tsien Hsue-shen (H.S.) came to MIT under the terms of the Boxer Indemnity Scholarship Program. When the western powers extracted indemnities from the Chinese government after the Boxer Rebellion, our country decided to use the funds to establish a scholarship to bring Chinese students to the United States and enroll them in our universities.

H.S. earned a master's at Tech in 1936 and then entered the California Institute of Technology. At that time, MIT programs tended to support practical engineering and industrial applications. Cal Tech, on the other hand, preferred a more theoretical approach and this perfectly suited the mathematically-adept Tsien. He studied under Theodore von Kármán, one of the world's greatest aerodynamicists, and, in 1939, received a doctorate based upon his study of the theory of slender objects at high speed.

Before and during World War II, von Kármán was working with an eccentric band of rocketeers and H.S. joined with them, supporting their rocket building enterprise and jump-starting the Army's missile program. Together, they founded the Jet Propulsion Laboratory (JPL) which supported the army's early missile program. When NASA was created in 1958, JPL was transferred to the new agency and payload development pushed rocket development into the background. At the end of the war, the USAF granted him the assimilated rank of colonel and he traveled to Europe with von Kármán to study German aerodynamic and rocket technology.

H.S. returned to MIT for a short time after the war and, in 1947, at the age of 35, was granted tenure as a full professor, possibly the youngest person ever to enjoy this honor. However, he received an offer in 1948 that he could not refuse. The Guggenheim Foundation decided to fund centers for jet propulsion research at both Princeton and Cal Tech. When Cal Tech also offered him seven years of research funding and a tenured chair as the Robert Goddard Professor of Jet Propulsion, he left the practical atmosphere in Cambridge for Pasadena's more theoretically friendly environment.

During the 1950s, H.S. was suspected of being a communist, based upon his attendance at meetings organized by the Communist Party and some thin documentary evidence. He lost his security clearance, was jailed, detained for a long period of time and suffered a wide range of indignities at the hands of the United States government. Finally, H.S. could stand it no longer and, in 1955, with difficulty, managed to return to the People's Republic of China where he was welcomed with open arms. Over the next 15 years, H.S. led the programs that ultimately resulted in the *Dong Feng* ballistic missile family and the Long March satellite launching vehicle.

The younger cousin, Tsien Hsue-Chu (H.C.) was also a beneficiary of the Boxer Indemnity Scholarship Program. After baccalaureate studies in China, H.C. entered the MIT aero program and received his master's in 1937, the same year that the Sino-Japanese War started. H.C. became a colonel in the Republic of China Air Force and, for the next eight years, was involved in the war effort. He traveled between the United States, Switzerland, China and India, designing equipment and coordinating logistics planning. At the end of the war, H.C. immigrated to the United States, became a naturalized citizen and rose to become Chief Engineer at Boeing.

This essay has only touched upon the extraordinary roles that MIT has played in the history of flight. Nothing has been said about contributions to aerial navigation: the Radiation Lab and LORAN, Charles Stark Draper and inertial navigation and Ivan Getting and Charles Parkinson and GPS. And what about propulsion and the work of the Taylor brothers or Carl-Gustaf Rossby, whose seminal work in atmospheric physics revolutionized meteorology was only mentioned? But these stories must wait for another opportunity to read and learn.

> ...our brain has undergone a true increase in size not related to the demands of our larger body. We are, indeed, smarter than we were. Despite this, we are not as smart as some people like to think we are.
>
> —Stephen Jay Gould
> "Sizing Up Human Intelligence"

Ammonia Pollution from Farming

[These extracts are from an article by Erik Stokstad in the January 17, 2014, issue of *Science*.]

A new analysis suggests that ammonia does even more health damage in the United States than was thought. The annual cost—associated with thousands of premature deaths—may even exceed the profit reaped by farmers. Some analysts say the startling numbers highlight the need for greater U.S. regulation of agricultural emissions and a review of farm subsidies….

Ammonia enters the air mostly from agriculture, although it can also come from vehicles and wildfires. Emissions are growing worldwide and are largely unregulated. When molecules of ammonia react with oxides of nitrogen and sulfur (NO_x and SO_x) created by burning fossil fuels, they turn into particulate matter less than 2.5 microns wide ($PM_{2.5}$)—the most dangerous kind, for which there is no known safe level.

An extensive study of the burgeoning hog farm industry in North Carolina, completed in 2003, found that ammonia-related $PM_{2.5}$ exacted higher health costs than other farm pollutants…. the average U.S. health cost of ammonia ranges from $10 to $73 per kilogram.

…Although the health toll varies greatly by location, the burden is heaviest in cities, because of the concentration of NO_x and people. And the total impact is eye-opening: about $100 per kilogram of ammonia, or $36 billion annually. In contrast, the net value of the exported food is $23.5 billion.

Some experts are skeptical of those numbers, pointing out that the new air pollution model has not yet been peer-reviewed and that the health effects of various $PM_{2.5}$ chemistries are still uncertain….

Recommended Reading

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

Bambrick-Santoyo, Paul; "Make Students College-Ready in High School"; *Phi Delta Kappan*, February 2014, pp. 72-73.

Ferguson, Maria; "Failure IS an Option"; *Phi Delta Kappan*, December 2013/January 2014, pp. 68-69.

Kolbert, Elizabeth; "The Lost World"; *The New Yorker*; December 16, 2013; pp. 28-38.

Rotman, David; "Why We Will Need Genetically Modified Foods"; *Technology Review*; January/February 2014; pp. 28-37.

Tegmark, Max; "Math Made Flesh"; *Discover*; December 2013; pp. 44-47.

Wegner, Daniel M. & Ward, Adrian F.; "How Google Is Changing Your Brain"; *Scientific American*; December 2013; pp. 58-61.

Woolston, Chris; "GMO Foods: Dangerous or Innocuous?"; *Reader's Digest*; January 2014; pp. 58-59.

Actionable Agenda Summary

The first MIT-GWU STEM Policy Institute was held on July 14-18 in Washington, DC. Twenty NEST members, a cross-section of the more than 1200 members, attended. The Institute was hosted by the Graduate School of Education at George Washington University. This is an experiment in collaboration between MIT and GW U that is intended to expand.

The motivation for this Institute is expressed coincidentally in the following statement from Bruce Alberts, the former President of the National Academy of Sciences, in the following excerpts from an editorial that appeared on page 249 of *Science* on April 19, 2013.

…[teachers] have many valuable suggestions for improving education systems. I am also painfully aware of the many past failures that have been caused by not giving the best teachers a strong voice in the public policies that profoundly affect their profession. In the 1980s, the Japanese taught the world that building a better automobile requires listening to workers on the assembly line. More generally, experience shows that actively soliciting advice from those most intimately involved is essential for wise decision-making at higher levels. Regrettably, education is one of the few parts of U.S. society that fails to exploit this fact. Hence, my initial Grand Challenge: "Build education systems that incorporate the advice of outstanding full-time classroom teachers when formulating education policy." A start has been made, but much more remains to be done….

Teachers are not often enough included in the decision making processes that affect their profession and their classrooms. A major goal of this Institute was to give them the tools to act on this omission. It is important to say that teachers should be seen as advisors and resources to policymakers, not as lobbyists. In the best circumstances, some teachers would become policymakers themselves.

The following is a summary of points which emerged from our conversations. Some of these items may be molded into an actionable agenda for the participants of this Institute and for teachers broadly. This summary is presented at this point for discussion purposes:

1 Few of the current population of legislators at the state and federal level were educated as teachers or scientists. Virtually every President identifies education as a priority and yet, what is lacking is direction, both in Congress and in the White House. The *expert* opinion of teachers regarding issues that affect their classrooms has been largely ignored by policymakers. This requires a cultural change that is long overdue. We can launch such a change. For example, teachers who have interest should be encouraged to seek public office.

2 The beneficiaries of the products of the K-12 system are universities and employers, both of which are key to the economic health of the nation. Pre-college teachers should be encouraged to interact with their university counterparts and with the business community.

3 The National Research Council (NRC) regularly populates panels with university academics and business people that address issues of importance to teaching professionals, often at the request of policymakers. The evolution of the Next Generation Science Standards and the development of the NRC's National Science Educations Standards in the 1990s are two well-known examples of a much more extensive spectrum. Teachers should be encouraged to serve and interact with their university and business counterparts on these nationally-visible NRC study committees.

4 Serving as described in (3) would require support from a teacher's school system. One valuable product of this inaugural meeting of the Institute could be to construct a document, available to teachers and their school systems, that identifies the merit of teachers taking on such leadership roles.

5 If not as lobbyists, how might teachers best influence policy decisions that affect their classrooms at the local, state and national level? A *flowchart* that identifies the processes that might be considered in response to a given issue could be worth developing to provide guidance to teachers on actionable responses. (See Helen Malone's Debrief Theme's from the Institute, July 25, 2013.)

6 Project 2061, the NRC Science Education Standards, Common Core, etc., all represent efforts at education reform. To be useful, there must be alignment of curricular materials with expressed standards and corresponding assessment vehicles. This poses two concerns: (a) which standard does a teacher/school system adopt, and (b) does assessment encourage a teach-to-the-test approach. The latter often carries the potential for abuse of students, teachers and schools. There is no doubt that teachers need to assess how well their students are learning. The policy issue which emerges is to consider whether a system based on school accreditation would be more effective, in terms of the education of young people, than a system based on high stakes assessment that may ultimately prove counter-productive. (For reference, note that accreditation boards review the curriculum and teaching practices at American research universities on a regular basis.)

7 We have reached a point at which it would be useful to launch a policy-oriented thread in the NEST Newsletter as a demonstration of the collaboration between the GWU and MIT. Historically, the MIT *Science and Engineering Program for Teachers* has been oriented toward a presentation of the frontiers in university research and education in the sciences, engineering and management schools. This new interaction with the GW Graduate School of Education and Human Development allows a natural and extraordinarily important expansion of our mission to include not only the descriptions of the STEM frontiers, but a meaningful voice in the evolution of educational policy which affects classrooms across the nation.

In its 2010 report[1], the President's Council of Advisors on Science and Technology (PCAST) observes that "…many STEM teachers are frustrated by unresponsive school, district, and state management systems. Unless we give our best teachers access to decision-makers and a voice in the many policy decisions that affect their lives, we will continue to make poor use of the talented teachers in our schools…Teachers need access to relevant professional support and to peers who have grappled with similar problems, and they need to feel that their work is respected and recognized. They need opportunities to serve as leaders among their peers and in their profession. In turn, we need to expect of teachers the accreditation and performance of professionals." The seven points above represent actions that address the PCAST observation and should be considered and prioritized in terms of an actionable agenda for NEST.

[1]Report to the President-Prepare and Inspire: K-12 Education in Science, Technology, Engineering and Math (STEM) for America's Future, PCAST, 2010, p. 73.

High School Years

[These excerpts are from an article by Maria Ferguson of GWU that appeared in the February 2014 issue of *Phi Delta Kappan*.]

Relatedness is when a student completes a task because doing so rewards the student with a sense of belonging or approval from an important person or institution. In high school, a student's relationships with teachers, coaches, and other important adults can profoundly affect their experience. It is counterintuitive that teenagers—so outrageous in their self-absorption—desperately need to feel connected to adults who care about them as individuals.

Unfortunately, growing class size, fewer guidance counselors, and a near obsession with test scores have made relationship building with students nearly impossible. The effect of this is never more damaging than on high school students seeking to become first-generation college-goers. Even if they master the academic requirements to get into college or to pursue a vocational apprenticeship, there is often no one in their lives who can advise them on how to apply to and pay for college or training. That feeling of confusion and isolation can overpower even the promising students, especially when no one is available to help.

The high school years are also a time to question and rebel against convention, so keeping students engaged in and excited about their work in class is crucially important. Research shows that a student's level of motivation can rise or fall based on whether the work they're doing has some practical application toward the kind of life they want after high school. The notion that students deeply engage in work that is project-based, collaborative, and directed toward a real-life situation or problem is not new….When managed by skilled teachers and incorporated into the culture of the school, project-based learning pulls students into the learning process like some gravitational force. If a lack of relevance is a major reason why students drop out of high school, then shouldn't more high schools be thinking about how they can develop project-based work for students?...

The world in which teenagers live when they are not in school has changed profoundly, more so than at any time in recent history. If high school is the home stretch in preparing them for life in the "real world," then we need to take a hard look at the policies and practices that currently define most American high schools.

The Teacher's Role

[These excerpts are from an op-ed article by Elizabeth A. Natale that appeared in "The Hartford Courant" on January 17, 2014.]

Surrounded by piles of student work to grade, lessons to plan and laundry to do, I have but one hope for the new year: that the Common Core State Standards, their related Smarter Balanced Assessment Consortium testing and the new teacher evaluation program will become extinct….

Unfortunately, government attempts to improve education are stripping the joy out of teaching and doing nothing to help children. The Common Core standards require teachers to march lockstep in arming students with "21st-century skills…."

The Smarter Balance program assumes my students are comfortable taking tests on a computer, even if they do not own one. My value as a teacher is now reduced to how successful I am in getting a student who has eaten no breakfast and is a pawn in her parents' divorce to score well enough to meet my teacher evaluation goals.

I am a professional. My mission is to help students progress academically, but there is much more to my job than ensuring students can answer multiple-choice questions on a computer.…

My most important contributions to students are not addressed by the Common Core, Smarter Balance and teacher evaluations. I come in early, work through lunch and stay late to help children who ask for assistance but clearly crave the attention of a caring adult….I "ooh" and "ah" over comments made by a student who finally raises his hand or earns a C on a test she insisted she would fail.

Those moments mean the most to my students and me, but they are not valued by a system that focuses on preparing workers rather than thinkers, collecting data rather than teaching and treating teachers as less than professionals….

Teaching is the most difficult—but most rewarding—work I have ever done. It is, however, art, not science. A student's learning will never be measured by any test, and I do not believe the current trend in education will lead to adults better prepared for the workforce, or to better citizens. For the sake of students, our legislators must reach this same conclusion before good teachers give up the profession—and the children—they love.

The Cost of Overtesting

[This brief article appeared in the Fall 2013 issue of "American Educator" and more details are available at http://bit.ly/1eMBDud.]

A close examination of two medium-sized school districts' standardized testing practices found that kids are losing out on a full, high-quality education because of pervasive test preparation and testing, according to an AFT report released in July. Test preparation and testing absorbed 19 full school days in one district and a month and a half in the other in heavily tested grades. The report found that cutting the amount in half would restore needed instructional time and provide additional funds for other instructional purposes.

Blended Learning in a Mathematics Program

Dwight Raulston [NEST '13]

The term blended learning means a great many different things in different contexts and to different people, but a common aspect seems to be a learning environment in which students are simultaneously independent and collaborative. Such an environment can be achieved in an old-style classroom, but it is definitely facilitated by what are generically called "information and communication technologies."

Around a decade ago, I became progressively more dissatisfied with math texts (specifically calculus, but the observation applied to most math texts back then) that might present interesting questions to students but which answered them either immediately or a page later. A student could be confident that answers would be coming soon. Most of the material that actually required a student's close attention was a "problem set" at the end of the section.

My objection was two-fold. The first is that no reflection was needed to the questions that the text raised; one could turn a page or two and find the author's desired answer without thought. The second is that the very large majority of material with which students needed to grapple was problems with very definite answers. Process was, as in most math courses, significantly undervalued compared to product. Not only that, but the product was nearly always a single correct answer.

I suspected that years of continued focus on finding the correct answer (and it was almost always "the" answer rather than "an" answer) contributed mightily to the nearly ubiquitous perception (except among university mathematicians) that mathematics was a black-and-white subject, where every question "has an answer" that a diligent student can find simply by memorizing enough algorithms and doing enough practice problems.

A few years previously, I had pioneered a re-engineering of my school's advanced mathematics program that would allow the top students in the class to take BC Calculus as juniors and then choose from a variety of post-AP options. Starting with Multivariable Calculus and Differential Equations, the options later came to include Linear Algebra, Partial Differential Equations and even Complex Analysis. All the courses (except Complex Analysis) relied heavily on two components that fostered a combination of student independence and cooperation. One was an online text, wherein students could not simply "turn a page" to find an answer to a question. The other was the use of a "personal tutor" or "research assistant" in the form of sophisticated mathematical software.

My goal was for students to read some material, make a conjecture about a plausible answer to a question asked in the online text and then use their "personal tutor" to check to see whether their guess might be correct—or might be leading in a useful direction. The software was also useful for those who, like me, were visual learners; it allowed them to make a mathematically accurate picture of the situation in question to then use as an object of reflection.

As the course enrollment grew (from about 15 out of 125 students in 2000-2001 to 29 out of 140 students this year), I found I needed to add more detail and more structure to the on-line notes. With the growth of mathematics information available online, students in the past few years have made extensive use of such resources in order to help them answer questions in my on-line text; nearly all of them, however, in spite of all the resources available, still work with a partner or larger group in order to test out their ideas before submitting their answers to the questions.

The availability of powerful software (we use *Mathematica*, but other programs are available) allows students to experiment with an "applied problem" (see the appendix for an example) to try to get an intuitive sense of what's going on before grappling with the mathematics. It's also extremely effective in aiding visualization (in Multivariable Calculus) and solving realistically complicated systems of equations (in Differential Equations). As the capabilities of online applets expand and as sites like Wolfram Alpha become more and more sophisticated, it may soon be the case that the "personal tutor" is as available and ubiquitous as an iPad or smart-phone.

I've spent most of this article talking about AP Calculus BC, but the ideas have been applied to a number of courses. In general, the post-calculus courses require increasing use of *Mathematica* and increasing student independence and collaboration. I have supplied some websites for those who might be interested. Please feel free to get in touch with me or my colleague, Daniel Friedman (dfriedman@sjs.org), who often teaches the linear algebra and partial differential equations courses. The original online text was a series of directed investigations that I call labs (by analogy with the way scientific inquiry proceeds) hosted on an internal server. At the request of students who wanted to be able to search an entire site, some of the courses have now been moved over to Google sites.

Trading teaching assignments with a colleague next fall, I'll be applying some of these ideas to 9th grade Honors Geometry, and I will update you on how things go.

Some course websites:

http://www2.sjs.org/raulston/MVC.14/index.htm
https://sites.google.com/site/math3dlr
https://sites.google.com/site/dlrmath5

Appendix—(A physics application in parametrics)

Consider an object shot or thrown from an initial height h above the ground at an angle θ (theta) with the horizontal and an initial velocity of v_0. The units of h and v need to be commensurate. Under such circumstances, it can be shown that the position vector of the object is

$$\mathbf{r} = \left\langle (v_0 \cos\theta)t, h + (v_0 \sin\theta)t - at^2 \right\rangle$$

where a is the acceleration due to gravity.

a. Write the equations $x(t)$ and $y(t)$ that control/reflect the object's motion.

b. In the common system of units, so despised by scientists but beloved by *hoi polloi* (including baseball fans), $a = 32\ ft/sec^2$.

c. The center-field fence in a ballpark is 10 ft high and 400 ft from home plate. "Slugger" Vogeley hits a ball that's 3 ft above the center of home plate, with the ball leaving his bat at an angle of θ degrees with the horizontal at a speed of 100 mph. A lucky hit of a fastball or amazing skill? You decide….

i) Write a set of parametric equations for the path of the ball.

ii) Plot the path when θ is 15, 20 and 25 degrees. For which of these angles (if any) is the hit a home run?

iii) Find the minimum angle at which the ball must leave Andrew's bat for his hit to be a homer.

Universal Laws of Complexity

[This excerpt is from a commentary by Geoffrey West entitled "Wisdom in Numbers" that appeared on page 14 in the May 2013 issue of *Scientific American*.]

The digital revolution is driving much of the increasing complexity and pace of life we are now seeing, but this technology also presents an opportunity. The ubiquity of cell phones and electronic transactions, the increasing use of personal medical probes, and the concept of the electronically wired "smart city" are already providing us with enormous amounts of data. With new computational tools and techniques to digest vast, interrelated databases, researchers and practitioners in science, technology, business and government have begun to bring large-scale simulations and models to bear on questions formerly out of reach of quantitative analysis, such as how cooperation emerges in society, what conditions promote innovation, and how conflicts spread and grow.

The trouble is, we don't have a unified, conceptual framework for addressing questions of complexity. We don't know what kind of data we need, nor how much, or what critical questions we should be asking. "Big data" without a "big theory" to go with it loses some of its potency and usefulness, potentially generating new unintended consequences.

When the industrial age focused society's attention on energy in its many manifestations—steam, chemical, mechanical, and so on—the universal laws of thermodynamics came as a response. We now need to ask if our age can produce universal laws of complexity that integrate energy with information. What are the underlying principles that transcend the extraordinary diversity and historical contingency and interconnectivity of financial markets, populations, ecosystems, war and conflict, pandemics and cancer? An overarching predictive, mathematical framework for complex systems would, in principle, incorporate the dynamics and organization of any complex system in a quantitative, computable framework.

We will probably never make detailed predictions of complex systems, but coarse-grained descriptions that lead to quantitative predictions for essential features are within our grasp. We won't predict when the next financial crash will occur, but we ought to be able to assign a probability of one occurring in the next few years. The field is in the midst of a broad synthesis of scientific disciplines, helping reverse the trend toward fragmentation and specialization, and is groping toward a more unified, holistic framework for tackling society's big questions. The future of the human enterprise may well depend on it.

Denial of Catastrophic Risks

[This excerpt is from an editorial of the same name by Martin Rees that appeared in the March 8, 2013, issue of *Science*.]

The main threats to sustained human existence now come from people, not from nature. Ecological shocks that irreversibly degrade the biosphere could be triggered by the unsustainable demands of a growing human population. Fast-spreading pandemics would cause havoc in the megacities of the developing world. And political tensions will probably stem from scarcity of resources, aggravated by climate change. Equally discouraging are the imponderable downsides of powerful new cyber-, bio-, and nanotechnologies. Indeed, we're entering an era when a few individuals could, via error or terror, trigger societal breakdown.

Some threats are well known. In the 20th century, the downsides of nuclear science loomed large. At any time in the Cold War era, the superpowers could have stumbled toward Armageddon through muddle and miscalculation. The threat of global annihilation involving tens of thousands of hydrogen bombs is thankfully in abeyance, but now there is a growing concern that smaller nuclear arsenals might be used in a regional context, or even by terrorists. We can't rule out a geopolitical realignment that creates a standoff between new superpowers. So a new generation may face its own "Cuba," and one that could be handled less well or less luckily than was the 1962 crisis.

What are some new concerns stemming from fast-developing 21st century technologies? Our interconnected world depends on elaborate networks: electric power grids, air traffic control, international finance, just-in-time delivery, and so forth. Unless these are highly resilient, their manifest benefits could be outweighed by the catastrophic (albeit rare) breakdowns cascading through the system. Social media could spread psychic contagion from a localized crisis, literally at the speed of light. Concern about cyberattack, by criminals or hostile nations, is rising sharply. Synthetic biology likewise offers huge potential for medicine and agriculture, but in the sci-fi scenario where new organisms can be routinely created, the ecology (and even our species) might not long survive unscathed. And should we worry about another sci-fi scenario, in which a network of computers could develop a mind of its own and threaten us all?

Some would dismiss such concern as an exaggerated jeremiad: After all, societies have survived for millennia, despite storms, earthquakes, and pestilence. But these human-induced threats are different—they are newly emergent, so we have a limited time base for exposure to them can't be so sanguine that we would survive them for long, or that governments could cope if disaster strikes….

No. Reading has not gone out of fashion in the last number of years....Your relatives do not wish to expose themselves to deep thought, lest they be affected by it.

—Anne McCaffrey & Jody Lynn Nye
The Death of Sleep

Flipped Learning: An Alternative Form of Classroom Instruction

Shannon Wachowski [NEST '13]

Flipped Learning is an instructional method that "flips" the location of instruction and practice. Introduction of material is accomplished outside of class through methods other than lecture, such as video, and class time is used for application of concepts, where students encounter the most challenges. I first learned of the Flipped Classroom instructional method in 2010 at the annual Colorado Association of Science Teachers conference. Aaron Sams and Jon Bergmann, pioneers in the area of flipped learning, presented on how this instructional method had changed their purpose in the classroom.

I decided to implement Flipped Learning as a way to better reach my students and provide more assistance with difficult chemistry concepts. Since that time, Flipped Learning has grown in popularity as evidenced by the large membership of the Flipped Learning Network (http://flippedclassroom.org) and growth of FlipCon (www.flippedlearning.org/flipcon14), an annual conference revolving around Flipped Learning.

Flipped Learning has four major pillars:

Flexible Environment

Having a flexible environment means reconsidering why certain things are done in the classroom. The three main parts include spacing, pedagogy and assessment. What does your classroom look like? Are students in rows, pods, or large groups? It is important to consider what type of spacing will best facilitate how you want students to interact with each other and with you, in the classroom. My classroom is arranged in pods of four with a designated testing area. Another factor in having a flexible environment involves pedagogy. Under the Flipped Learning Mastery model, students work *at their own pace* and take assessments when ready. This means that students are not all doing the same thing on the same day. This can seem scary to some teachers so it is up to you to decide how much control you are willing to give up. Because tests are not just given on specific days, several versions of the test must be available and under some versions of Flipped Learning, alternate assessments, including projects and different test formats, are also options. Again, this depends on your comfort level.

Learning Culture

This pillar involves a shift in responsibility of learning from the teacher to the student. Under the Flipped Learning model, students can no longer "play" school by coming to class, taking notes, and memorizing how to do problems in preparation for a test. I am constantly formally assessing my students and if a student does not demonstrate understanding of a topic, I am able to clear up misconceptions and provide further practice or instruction on the spot. Some students do not like this system, as it places the responsibility of learning on them. To incorporate a culture focused on learning, conversations need to change from an emphasis on points and grades to an emphasis on mastery of concepts and the learning process. One way to help accomplish this is through the use of standards based grading. After implementing some form of Flipped Learning for the past 3 years, I am just now starting to see a change in classroom culture. This is a long process that requires buy-in and support from administration, students and parents.

Intentional Content

One major misconception about Flipped Learning is that it's all about videos. This is so far from the truth! Use of videos is one way to distribute content to students while using class time for the more difficult part of the learning process: application of content. Flipped Learning is about active learning in the classroom, not passive dissemination of information. The Flipped Learning model has helped me become more intentional with my content. I now act as a filter to help students decide what information is useful instead of just telling them what is important. This is where 21st century skills are truly applied. I also give my students choices on how to accomplish objectives through the use of several learning objects.

Professional Educator

Making any change can be difficult. Inform all involved parties to ensure consistent expectations among all groups. Flipped Learning can be implemented several different ways, so start small. Try flipping one section or just start by recording your lectures. Also, don't do it alone! When I decided to try Flipped Learning, I was the only one in my school who thought it was a good idea. That first year was a struggle with my students and with myself. However, I didn't give up! I kept making iterations to the process and started networking with other teachers who flip. Now, another science teacher in my building is flipping all of his classes and several other teachers are interested in trying the process. Although the system isn't perfect (what system is?), I feel it is the best method for me. That's what you need to decide—what works best for you? Learning is a human process and one size doesn't fit all. Every day I do my best to connect with as many of my students as possible and create an environment that helps them develop the skills to be successful. Flipped Learning helps me accomplish that goal.

"Less us, more them. That's the real flip that needs to happen."

—Frank Noschese

Along my Flipped journey (and it isn't over yet!) I've utilized several tools:

- Flipping 2.0 - Practical Strategies for Flipping Your Class
- FlipCon 2013
- Flip Your Classroom: Reach Every Student in Every Class Every Day by Aaron Sams and Jon Bergmann
- Flipped Learning Network Ning *http://flippedclassroom.org* (includes research)
- Clintondale HS (near Detroit) *www.flippedhighschool.com*
- Research on Flipped Learning *http://flippedlearning.org/research*
- Blog by Dr. Ramsey Musallam *www.cyclesoflearning.com*
- Blog by Crystal Kirch *http://flippingwithkirch.blogspot.com*
- Blog by Brett Clark *www.educationdreamer.com*
- Blog by Jon Bergmann *http://flipped-learning.com*
- Twitter: #flipclass, #flipclassroom
- Hosting Videos: Sophia *www.sophia.org*, LessonPaths *www.lessonpaths.com*, YouTube *www.youtube.com*, TeacherTube *www.teachertube.com*, Edmodo *www.edmodo.com*,

Edline *www.edline.net/Index.page*

- Video Editing Software: Jing *www.techsmith.com/jing.html*, Camtasia *www.techsmith.com/camtasia.html*, Debut *www.nchsoftware.com/capture/index.html*

Note: The purpose of this article is an introduction to Flipped Learning. For more information on specifics or if you have questions, please contact me at shannonwachowski@gmail.com!

Continued from page 1 "Ed Reform: Vision-Impaired"

and mathematics (STEM). This was not done by listening to lecture after lecture, but rather through hands-on activities and simulations that we could bring back and implement in our classrooms. For example, we modeled DNA using LEGOS, experienced sustainability within an ecosystem through a computer simulation called Fishbanks, toured laboratories at Koch Institute to learn about the use of nanotechnology in cancer, used web based microscopes to become citizen scientists and discovered how to use MIT Mathlets in the classroom. This is only just a small sample of the flood of information that occurred as the result of MIT's unique fire hose.

As part of the summer workshop experience, all the participants lived in a dorm on campus. This immersed us in MIT's culture of creativity, innovation, problem solving and—yes—even hacking. (The word hack at MIT usually refers to a clever, benign and "ethical" prank or practical joke, which is both challenging for the perpetrators and amusing to the MIT community (and sometimes even the rest of the world! http://hacks.mit.edu). During the evenings, this group of master teachers from around the world got together to explore Boston, share stories, discuss best practices and plan our hack for our stay at MIT. You can just imagine what the energy and creativity was like in a room full of top educators.

Educate…Engage…Inspire…that is what makes MIT's SEPT workshop one of the most powerful professional development workshop that I have ever attended. After my week at MIT, I could not wait to get back to school to share and implement everything I learned. Luckily, this amazing learning experience does not stop here. Having completed the SEPT program, I can now participate in NEST (Network of Educators in Science and Technology). Through this fellowship program, participants stay connected to MIT and continue their learning. Members of NEST are invited back to MIT for a workshop every June, receive the NEST newsletter and information on summer research opportunities, are able to give an MIT student recognition award and much more.

I am grateful to the MIT Club of Hartford for giving me the opportunity to attend this unique professional development opportunity. I strongly encourage other educators to seek out their local MIT Alumni Club. Many of these clubs annually select a local teacher and award a scholarship to cover the SEPT course tuition, plus an allowance for incidentals and transportation to MIT. Apply to the SEPT program and experience MIT with its innovation, cutting edge research, resources, passionate professors and entrepreneurial spirit.

For more information on the SEPT program, go to: http://web.mit.edu/scienceprogram.

Brain Exports

[These excerpts are from an article by Harold O. Levy that appeared in the December 2013 issue of *Scientific American*.]

…The unpleasant truth is that the U.S. public education system simply does not produce enough high school graduates who are qualified for college work of any kind, let alone students with a vigorous appetite for math and the sciences. The full depth of America's educational failure is actually masked by the diversity of nationalities among grad students in those fields: Of the 1,777 physics doctorates awarded in 2011, for example, 743 went to temporary visa holders from many lands—and that figure excludes foreign nationals who had won permanent resident status. Only 15 of those 1,777 doctorates were earned by African-Americans.

…In 2009, the most recent year for which such data exist, students on temporary visas earned 27 percent of all master's degrees in science and engineering, including 36 percent of those in physics and 46 percent in computer science. And a 2002 survey found that nearly 30 percent of those candidates had no form commitment to lives in the U.S. after graduation….

…If current trends continue, America's scientists and engineers—the basic drivers of innovation and prosperity—will ultimately be surpassed by U.S.-educated competitors in other countries that are more serious about teaching their youngsters.

To keep this from happening, America needs to strengthen math and science programs from kindergarten through grade 12….

…The alternative is to keep on allowing the country's great universities to be used as a funnel for unintended foreign aid.

The Fourth Dimension

[This excerpt is from page 10 in a book by Rudolf v. B. Rucker entitled "Geometry, Relativity and the Fourth Dimension."]

After the sphere showed himself to A. Square, A. Square remained unconvinced. So A. Sphere did some more tricks. First he removed an object from a sealed chest in A. Square's room—without opening the chest and without breaking any of its walls. How was this possible? A chest in Flatland is just a closed 2-D figure, such as a rectangle. But we can reach it from the third dimension without breaking through the trunk's "walls".

The analog is that a 4-D creature should be able to, say, remove the yolk from an egg without breaking the shell, or take all the money out of a safe without opening the safe or passing through any of its walls, or appear in front of you in a closed room without coming through the door, walls, floor or ceiling. The idea is not that the 4-D being somehow "dematerialized" or ceases to exist in order to get through a closed door. Your finger does not have to cease to exist for an instant in order for you to put it inside a square. The idea is that since the fourth dimension is perpendicular to all of our normal 3-D space directions, our enclosures have no walls against this direction. Everything on Earth lies open to a 4-D spectator, even the inside of your heart.

How Many Famous Female Scientists Can You Name?

Sarah Hollingsworth [NEST '13]

Nothing says "Welcome to back to school night" like a firm handshake directly followed by "What is the school doing to engage girls in STEM activities?" This isn't usually how parents greet me and, after I collected my wits, I have to admit that it made me take a serious look at gender and science in my classroom. I am a female marine biologist and, after attending SEPT 2013 and a couple diversity conferences this past year, I know that I have bought into the gender gap. The challenge with our cultural system is that we are all in it. Girls are being marketed to at infancy with pink bows and princesses everywhere. You might say that the marketing is really to the parents because an infant certainly doesn't dress herself, but that's the point. We've bought into it and, as adults, we should know better. We often speak about racial perspectives when it comes to our country's history, and we are still struggling to break the habit of viewing our past from the white, male perspective in the classrooms. This is only one perspective, and I would challenge every science teacher, male or female, to really look at the subtle messages being sent to our students. How many perspectives do we offer in the lab?

When you look at the walls, how many faces of famous scientists are there? How many non-white males are there? I realized that I didn't even have my own gender well-represented in my very own classroom. Marie Curie was the lone lady hanging on the wall, and she died in 1934. Because she was a woman and chose to dress more like a man, she was denied access to advanced education in her homeland, and she was almost denied credit for the Nobel Prize in Physics. Have there not been any female scientists since then? Who is winning the Nobel prizes these days? These questions made me think beyond my classroom to the news, to scientific research and to my own male-dominated perspective.

I desperately wanted to show my students that real people, not just guys in lab coats, are doing amazing science as we speak. I thought about the many women who gave inspirational talks about their cutting edge research at the Koch Institute for Integrative Cancer Research while I attended SEPT last year. How could I take that feeling back to my classroom? Fortunately, Professor Cathy Drennan's chemistry videos offered a doorway to one solution. If you teach chemistry or just want to show kids real scientists who are not, as Cathy put it, "old, dead white men with beards," I highly recommend visiting her site: http://chemvideos.mit.edu. Her words inspired me to think about how I portray science to kids and, consequently, how it was portrayed to me. It happens that I love science and see it in everything down to the molecular level. But what about the kids who simply aren't that into science? How old is that black and white poster of Marie Curie on the wall? How do you get a teenager to think that electron orbitals are worth knowing about? You show them a variety of relatively young people telling them about their research. It doesn't hurt that one or two videos involve explosives. There were no new science posters for me to order, so I turned to the Internet.

Because I wanted kids to connect to science and see women in science, I began to look beyond the MIT chemistry videos by Dr. Drennan. I was thrilled when I found videos on www.nbclearn.com about the science and engineering of the 2014 Winter Olympics. While my students loved seeing a short clip before our physics labs, I realized that almost all of the athletes and scientists were men. One of the most interesting videos that I have found on Newton's Laws is done through NHL hockey—again, all men. When I asked a few of my eighth grade girls to share their thoughts on how we were promoting science to female students, I was rather surprised. One student said that she felt the teachers did a great job making science interesting, and she found the use of videos helpful in showing her how science connected to real life. Ironically, this is the same student who pointed out to me earlier in the year that a lot of the video clips we were watching in class were narrated by men. Are we still losing our audience of young females, though, because science is still a man's world?

Let's move out of the classroom into extra-curricular activities. I asked a very popular and very academically capable eighth grade girl why she wouldn't consider joining the math league, the coding club or the robotics team. Before you start making pocket protector jokes, there were a few girls already in each of these clubs, including one female adult advisor. Most of the girls, however, were not part of the mainstream social crowd. I knew that the girl with whom I spoke was interested in math and science, but her social interests outweighed an opportunity to stay at school during her free time and program Arduinos and robots. I decided to lay my cards on the table and tell her that she had the social capital to join one of these clubs if she wanted to and that she would be really good at whatever she does. Her response was that they just didn't interest her. She suggested that a cooking class would be cool, and she was really interested in learning the chemistry of cooking. My point here is that thinking that science is interesting is not the same as being interested in it. What if we used what is already marketed for girls to steer them towards science?

As teachers, we want our girls to get into engineering, but in so many ways it is marketed to boys from the way the parts look, to the colors, to the objectives, and the list goes on. Are we really marketing anything to girls, or are we just telling them that boy toys are cool, too? I think there is a huge difference. Is it enough to paint LEGO blocks pink and purple, or do we actually take things that interest girls developmentally or culturally and infuse aspects of engineering and science like Debbie Sterling, inventor of GoldieBlox? "By designing a construction toy from the female perspective, we aim to disrupt the pink aisle and inspire the future generation of female engineers." This isn't about taking anything away from the boys; it's about changing the role of women in science. It isn't enough for girls to enjoy science class; we have to inspire them to be the next great thinkers of a generation.

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

Please send articles to:
Avi Ornstein, **ornstein@alum.mit.edu**

NEST in DC

Left is the total contingent that attended last summer's GW-MIT STEM Policy Institute.

Front row (left to right): **Sharon McCue [NEST '92]**; **Steven Cremer [NEST '91]**; **Kristen Record [NEST '11]**; **Kathleen Segale [NEST '08]**; **Ron Latanision—NEST Founder;** Michael Feuer—Dean of the Graduate School of Engineering and Human Development—George Washington University; **Donna Rand [NEST '00]**; **Avi Ornstein [NEST '89]**; **Helen Flavin [NEST '10]**.

Middle row (left to right): **William Smith [NEST '03]**; **Teresa Caracciolo [NEST '02]**; **Joyce Gleason [NEST '92]**; **Julie Crawford [NEST '12]**; **Susan Kelly [NEST '10]**; **Julianne Opperman [NEST '97]**; **April Lanotte [NEST '08]**.

Back row (left to right): Joe Scheller—CEO (ret.) Silberline & sponsor of NEST; **Ernie Smoker [NEST '07]**; **Mark Hungate [NEST '90]**; **John Steczak [NEST '02]**; Bernice Nowak-Ornstein.

Here (right) is our Massachusetts contingent meeting with their senator, Elizabeth Warren, at last summer's GW-MIT STEM Policy Institute. Those in the picture are **Mark Hungate [NEST '90]**, **Helen Flavin [NEST '10]**, Senator Warren and **Steve Cremer [NEST '91]**.

Here (left) is our Connecticut contingent meeting with both of their senators at last summer's GW-MIT STEM Policy Institute. Those in the picture are Senator Richard Blumenthal, **Susan Kelly [NEST '10]**, **Avi Ornstein [NEST '89]**, **Kristen Record [NEST '11]**, **Ernie Smoker [NEST '07]** and Senator Chris Murphy.

Computer Foresight

[This is the opening excerpt from "The Real Privacy Problem," an article by Evgeny Morozov that appeared in the November/December 2013 issue of *Technology Review*.]

In 1967, The Public Interest, then a leading venue for highbrow policy debate, published a provocative essay by Paul Baran, one of the fathers of the data transmission method known as packet switching. Titled "The Future Computer Utility," the essay speculated that someday a few, big centralized computers would provide "information processing…the same way one now buys electricity."

> Our home computer console will be used to send and receive messages—like telegrams. We could check to see whether the local department store has the advertised sports shirt in stock in the desired color and size. We could ask when delivery would be guaranteed, if we ordered. The information would be up-to-the-minute and accurate. We could pay our bills and compute our taxes via the console. We would ask questions and receive answers from "information banks"—automated versions of today's libraries. We would obtain up-to-the-minute listing of all television and radio programs…The computer could, itself, send a message to remind us of an impending anniversary and save us from the disastrous consequences of forgetfulness.

It took decades for cloud computing to fulfill Baran's vision. But he was prescient enough to worry that utility computing would need its own regulatory model….

ICT's Influence on Learning: Reflections and Possible Applications

Alejandro Grahl [NEST '13]

Previous considerations and using ICT in Argentina, nowadays

"Educational Technology can be defined as the body of pedagogical and didactic knowledge constructed from derivations of different disciplinary fields related to teaching practices in which technological developments impact." (Edith Litwin. Argentine Specialist in Education)

Most of us, while being formally educated, went through different stages of learning in which behaviorism, cognitivism and constructivism were the prevailing learning theories, depending on the era. Many of us didn't even know we were under their influences when we were sitting in the classroom. Today, and for some years now, the advent of technology (with different degrees of impact) has given rise to the so-called theory of connectivism, developed by George Siemens.

Connectivism is the use of networks to describe knowledge and learning. In the complex society in which we are immersed, knowledge is distributed and interconnected. Knowledge is then distributed through a network of individuals and, increasingly, technology agents. Learning is the process of enhancing and shaping these knowledge networks. Connectivism focuses on rapidly changing learning informational environments.

A theory of learning must also consider the widest possible context of the society in which it develops. For this, connectivism emphasizes the value of technology in revealing connections (e.g., visualization), allowing new associations and generally spreading the cognitive ability of people to treat their connected networks and technologies like cognitive agents.

The Information and Communication Technologies (ICT) have profoundly changed the ways of transmission, classification and processing of information. For example, the way we live and understand the contemporaneity. Inevitably, these changes affect "what is learned," "how it is learned" and "what people need to learn." ICT should play an active role in questioning the processes of teaching and learning and in helping to find new ways to design, lead and develop them.

Larry Cuban (an American education historian) analyzes the effects of changes in education and he refers to first and second order changes. The first order changes alter the effectiveness of the operation, without changing the basic organizational features of the institution. By contrast, the second order changes renew the structure and culture of schools and propitiate a restructuring of the way of understanding education and learning.

In general terms, the isolated use of ICT involves first order changes, but it is desirable to expect the trending points to favor second-order changes in which the institution can plan an integration project. In it, the aims should be defined; it should be clearly established how to get the necessary means and how to fulfill a strategy that enables ICT to substantially improve teaching and learning. It should also contribute to the professional development of teachers.

To achieve this, we understand that the key is the curricular integration of technology, taking this as an enriching element. Thus, the methodology used (implicit and explicit) represents a mediating role between content and technology tools, in order to generate actions that encourage, develop and improve collaborative learning.

In Argentina, we particularly think that there is a full awareness of the need to adapt infrastructure, teachers and students and leave no room for distraction. Many institutions (at all levels) make efforts to accomplish this with the ultimate inclusion of new technologies in their curricula.

The federal government encourages this process by generating plans that follow the so-called "OLP model." The main program, called Conectar Igualdad, tries to ensure the access to computers for all public school students. [The Conectar Igualdad Program is an educational strategy to revalue the public school, improve learning and reduce social, educational and digital division, by providing laptops to students and teachers, updating forms of education, strengthening the teacher's role and the production of educational content and resources.
—Source: Ministry of National Education, Argentina. Evaluative Studies PCI]

Obviously, a lot of problems are being faced. We think one of the greatest is the lack of curricular updating in the Institutions where future teachers study. It may be due to the major debt that has to be paid off. We consider (among other essential reforms) that ICT's teaching and learning process must be formal, systematic, thorough and consistent with the complex reality that future teachers will find. Undoubtedly, this challenge involves all actors in the system who wish to improve learning through ICT. For that, there must be an underlying pedagogical project, which will be decisive for the success or failure of the needed reform.

"Environmental Education: Application of New Technologies in the Classroom" (Project Director: Ing. Jorge Poliszuk)

This project was developed by authorities and professors (of which I am one) of the Environmental Engineering career, at the University of Tres de Febrero (Buenos Aires, Argentina) and carried out in Junior High and High School No. 21, in Hurlingham, Buenos Aires, Argentina. Its Headmistress, Mrs. Graciela S. Poliszuk, made unimaginable efforts to get teachers involved with the project, and great results were obtained.

Objectives of the project:

1. Promote permanence of the pupils in class
2. Democratize the use of ICT and teaching practices
3. Get pupils' families to be closer to school
4. State new didactical strategies
5. Promote working and debate networks
6. Train teachers in all levels
7. Create teaching materials to be used in class

It is important to remark that the school is located in the suburban area of Buenos Aires, with a population of students who mostly have serious emotional difficulties—in their families and in their personal environment. Absence of pupils was one of the major problems the school's authorities had to face.

Some results:

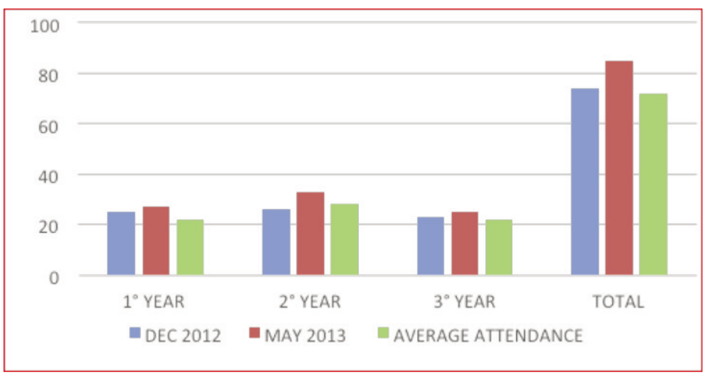
Since the Argentine government delivered Netbooks to pupils, absenteeism has strongly decreased; the total amount of pupils has been maintained or even increased; and the average attendance to classes has kept at historical figures or has even increased.

One of the achievements was the making, installation and testing of a chlorinator. The area where the school is situated has serious problems with a clean water supply. Pupils, teachers from the school and professors from the university worked together, concluding that a chlorinator should be installed to serve the school and also the local neighborhood. Also, they began a program to recycle plastic bottles.

Besides the teachers' and pupils' commitment with the project, the permanent use of Netbooks in every subject (with many of the students facing Word, Excel and Access for the very first time in their lives) and the understanding of using ICT as an essential tool were the other positive results.

This project was presented and explained by pupils and teachers at several Science Fairs.

COURSE	DEC 2012	MAY 2013	AVERAGE ATTENDANCE
1st YEAR	25	27	22
2nd YEAR	26	33	28
3rd YEAR	23	25	22
TOTAL	74	85	72



Final Thoughts

The experience gained in the implementation of the above project allows us to state that:

a) The proper use of ICT to enrich the teaching and learning processes improves, among other equally important factors, the inclusion and retention of students in classrooms.

b) The proper use of ICTs in the classroom compels teachers to involve their use in the class.

c) The influence of a headmaster or headmistress on teachers and an appropriate checking of that job define the results of ICT implementation.

d) The government should continue providing technical infrastructure and prepare teachers to achieve the objectives.

e) The education of future teachers should include ICT as a central focus in their curriculum.

References:

- Educación y tecnologías: las voces de los expertos. Silvina Gvirtz y Constanza Necuzzi (comp.), ANSES, 2011
- Educación y TIC. Alejandro F. Grahl. Editorial Académica Española, 2011
- Educación: Riesgos y promesas de las nuevas tecnologías de la información. Nicholas Burbules y Thomas Callister, Granica, 2008
- El oficio de enseñar - Edith Litwin, Paidós, 2008
- Enseñar para la comprensión - Martha Stone Wiske, Paidós, 2006
- Imaginar con Tecnologías. Carina Lion, Stella, 2006
- La aldea global. Marshall McLuhan y B. R. Powers, Gedisa, 2005
- La educación a distancia. Temas para el debate en una nueva agenda educativa. Edith Litwin, Amorrortu, 2003
- La tarea de educar. De qué hablamos cuando hablamos sobre educación. Juan de Pablos Pons (coord.), Biblioteca Nueva, 2003
- Los siete saberes necesarios para la educación del futuro. Edgar Morin, UNESCO, 1999
- Más allá de la tecnología. Aprendizaje infantil en la era de la cultura digital. David Buckingham, Manantial, 2008
- Modelos de enseñanza en la formación online. Lourdes Morán. Editorial Académica Española, 2011
- Tecnología Educativa. Julio Cabero Almenara (comp.), Mc Graw Hill, 2007
- Tecnologías educativas en tiempos de Internet - Edith Litwin (comp.), Amorrortu, 2005
- Tecnologías en las aulas. Las nuevas tecnologías en las prácticas de la enseñanza. Casos para el análisis. Edith Litwin, Mariana Maggio y Marilina Lipsman, Amorrortu

Learning Strategies

[This aside accompanied an article by John Dunlosky that appeared in the Fall 2013 issue of "American Educator."]

Based on our review of the literature, here are a handful of suggestions for teachers to help students take advantage of more-effective strategies.

- Give a low-stakes quiz at the beginning of each class and focus on the more important material. Consider calling it a "review" to make it less intimidating.
- Give a cumulative examination, which should encourage students to restudy the most important material in a distributed fashion.
- Encourage students to develop a "study planner," so that they can distribute their study throughout a class and rely less on cramming.
- Encourage students to use practice retrieval when studying instead of passively rereading their books and notes.
- Encourage students to elaborate on what they are reading, such as by asking "why" questions.
- Mix it up in math class: when assigning practice problems, be sure to mix problems from earlier units with new ones, so that students can practice identifying problems and their solutions.
- Tell students that highlighting is fine but only the beginning of the learning journey.

Bringing Why to Generation Y Science Education:
Molecular Modeling Approach to Protein Structure/Function Curriculum

AP Biology Level (Part 1)

Helen J. Flavin [NEST '10]

The entire module is designed to be run as teacher-guided student inquiry. This requires four days of class (including one double or lab period). At the end of the segment, students will have prepared their own assessment (study guide) for the materials that can be used as one assessment for the module. Day five is the single class period introduction to one project for extension. Over the next week, as homework, students then complete the project for extension as a lab or additional project assignment. During this period, as a review tool, traditional lecture PowerPoint slides for the chapter can be made available to students who wish to view them. The summative evaluation (exam) can be given any time after students have completed their initial study guide.

Two aspects deserve special mention at the outset. First, in order for maximum success with this process, the teacher must circulate continuously throughout the room, speaking with the individual students about what they "see" in the models. Such discussions are critical in that they provide a context for the student to continually be the science expert on that topic. This educational process also has the advantage of providing for immediate correction of student misperceptions. Second, assessment sheets for the study guide portion of the assignment should demand that students hand draw the figures. This emphasizes student creativity in preparing a figure to tell the protein story the student is evaluating. One important example of this is the assessment of intermolecular forces of attraction holding the shape of secondary and tertiary structures of proteins. An instructor must take the time to examine the internet resource the students will use and then select a list of amino acids to be used by the students (in their figures) that contains alternative amino acids of similar chemistry. Students are then required to utilize, in a new context, the information they have mastered regarding the chemistry of functional groups. This pays dividends later in the extension project or even later in the year when students study translation and meet conservative and silent mutations.

The first objective for students is the ability to recognize the amino acid building block molecules and to be able to explain how a polypeptide can be described as a heteropolymer held together by peptide bonds. The ChemPages Netorials Protein Module 1 (www.chem.wisc.edu/deptfiles/genchem/netorial/modules/biomolecules/modules/protein1/prot12.htm) can be used by individual students as a step-by-step interactive walkthrough of the chemistry of amino acids and proteins. Students also need a black and white sheet of amino acid structures (such as the one at www.personal.psu.edu/staff/m/b/mbt102/bisci4online/chemistry/chemistry8.htm). Once they recognize the common amino acid motif of amino group—alpha carbon—carboxylic acid, they can focus attention to the chemistry of the side chains. At this level, they are not required to memorize structures. However, color coding the side chains based upon polarity allows the students to later use the amino acid chart to predict how proteins will fold. In addition, this resource sheet now has the chemistry summarized that will allow students to understand (rather than just memorize the words for) the chemical nature of the intermolecular forces holding proteins to their specific shape. Finally, having the students find and list both the 3 letter and 1 letter abbreviations for the amino acids completes this tool.

After students can identify the four parts of an amino acid, they should use both a traditional (hands-on) molecular modeling kit and a computer modeling program to build some amino acids. Taking the time to do this allows students to make the connection between their prior knowledge of chemistry and the new material that depends on the chemical nature of the protein biomolecules. Students should build a minimum of three amino acids. For the computer modeling aspects, there is a freely available ChemSketch program from ACD/Labs (www.acdlabs.com/resources/freeware). Students readily discover for themselves how to use this to draw molecules. However, please see the appendix for those who wish directions for using the program to sketch and view the structure of amino acids.

On page 5, ChemPages Netorials Protein Module 1 has a three-step analysis of dehydration synthesis that will guide students through this process with their models. With the hands-on molecular modeling kit, students should place two amino acids side by side. Each amino acid (aa) has the amino group on the left and the acid group on the right. Students should remove one hydrogen from the amine on the right and the hydroxide (-OH) from the acid on the left. Then, they should form the amide bond known as the peptide bond. Half the students make the peptide using aa1, then aa2 and then aa3 while the other half make the peptide using aa3, then aa2 and then aa1.

Building and then orienting the molecules properly illustrates the loss of water and shows the new peptide bonds. After they explain it successfully, they then prepare their sheet, detailing the reaction. Have the two groups compare peptides (models and paper). They will have "discovered" that peptides can be made with the same amino acids, yet be different. Students will be aware of the importance of the sequence of the amino acids. For assessment, have students randomly choose amino acids and then draw a polypeptide with five peptide bonds! They are using the CB sheet for the necessary organic chemistry details, but developing that analytical ability to recognize peptide bonds, a polypeptide backbone and the fact that the amino acid R groups stick off that backbone. Have the students use page 7 of ChemPages Netorials Protein Module 1 to decide how to name their polypeptide.

In addition to mastering the first objective, students have an understanding that the nature of the polypeptide depends upon its chemical components. Also, they have learned the coloring system that will allow them to chemically analyze the atoms in any biomolecule. In addition, they have discovered their own answer as to how multiple proteins can be made from the same components (the same amino acids), yet chemically are different from each other. From there, it is a small leap to hypothesize that each specific structure has its own unique and specific functions.

Finally, they recognize the backbone of a polypeptide and the hydrophilic and hydrophobic nature of the side chains extending from that backbone.

The second objective is for students to be able to explain the four levels of protein structure. With the above emphasis on the chemical nature of the protein polymer, students are also ready to appreciate the intermolecular forces of attraction that hold the protein's shape. Available resources (http://mw2.concord.org/public/part1/insulin/insulin1a.cml) allow students to work through the four levels of protein structure for the protein insulin. This interactive module has students go through four steps: translate the primary sequence from the three letter code to the name for the amino acid; examine the molecular model (color-coded backbone) for the protein insulin to find cysteines involved in disulfide bridges; heat denature the insulin protein; and, finally, examine the function of the protein in reducing blood sugar and the molecular mechanism of this process.

Two aspects of this resource deserve special mention. First, the students can fold the protein in both oil and water. This allows them to observe that the protein folds differently in the different solvents. (Many students need a hint or reminder that oil is hydrophobic.) They then can readily understand that the hydrophobic side chains do not need to huddle up in oil. Second, for the folded protein (water as solvent), students can change the view to a wire-frame or to a ball-and-stick model. This allows them to move from the primary structure names (beads) on the string in order to see secondary structure highlights.

Next, on page 4, students can click on a picture of insulin that opens to an image that highlights intermolecular forces holding the protein shape. The backbone for the protein is outlined with the amine—alpha C—acid units within that backbone. Cysteine side chains have the covalent bond of the disulfide bridge. Finally, H-bonds between amine and acid moieties of backbone structures are also illustrated. A further interactive resource to explore intermolecular forces (https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/protein2.htm#aacd8b) allows one to scroll down to the secondary and tertiary structure of proteins. There are tabs that allow a student to visualize different models: wire-frame; ball-and-stick; ball-and-stick with backbone highlighted (and side chains sticking out); and alpha helix ribbon (with side chains extending out). The H-bonds stabilizing the helix are shown. A bit further down the page is a similar analysis for beta-sheets.

For assessment, students should be able to draw a figure similar to figure 8 (tertiary structure) at http://cnx.org/content/m44402/latest/?collection=col11448/latest that illustrates salt bridges, H-bonds, hydrophobic intermolecular forces (IMF) and covalent bond disulfide bridges. They should be able to use their coloring book sheet for amino acid side chains to allow them to draw their own figure. As they label each type of interaction, they should also explain the chemistry behind the attractive force. Next, by exploring www.elmhurst.edu/~chm/vchembook/568denaturation.html (which speaks about denaturing agents for proteins and explains how each agent works and shows the before and after molecular modeling picture for an example protein), students should be able to explain how each denaturing agent disrupts certain types of IMF, thereby disrupting the tertiary structure. As an assessment, have students use one or more chemicals on their "normal" protein figure noted above. They should have the before and after picture of the protein that illustrates the opening up or loss of structure with the denaturing agent.

Students can now readily explain how a protein can have hydrophobic parts and yet still "survive" in polar water molecules. They are ready to begin the challenge of predicting where substituted hydrophilic and hydrophobic amino acids will end up after a linear protein folds. Page 6 of the resource at http://mw2.concord.org/public/part2/pna/index.cml provides students with an interactive platform that allows them to build a polypeptide of their choice, hypothesize how it will fold in water and then run the modeling program to verify their polypeptide behaves as expected. In addition, pages 1-5 are an excellent interactive review of protein structure. If you allow students to use their amino acid coloring book page as a resource on test day, you can give them a linear sequence of amino acids. Students can then predict how this polypeptide will fold and insert into a lipid bilayer. Some students will place the hydrophilic residues inside the cell, but some will place them outside the cell. After the test, one can use that question to begin a discussion of what benefits there might be to a protein that has a region outside the cell, spans the membrane and then has a region inside the cell.

Quaternary protein structure can be examined with the model protein hemoglobin. One resource is http://mw2.concord.org/public/part2/hemoglobin/page1.cml and another is www.umass.edu/molvis/tutorials/hemoglobin. It is exceedingly important for students to explore both a protein that is active with a final tertiary structure (single polypeptide) as well as a protein that exhibits cooperative activity with quaternary structure. This serves to prevent common student misperceptions regarding quaternary structure.

An excellent review of the above topics in protein structure and function is provided at www.chem.wisc.edu/deptfiles/genchem/netorial/modules/biomolecules/modules/protein2/prot21.htm. It has the additional advantage of utilizing Jmol images of proteins for this review. (Jmol is an interactive web browser.) It thus provides an excellent bridge to independent molecular modeling activities.

The lesson module to this point essentially brings a student to an understanding of all the required protein structure concepts required with the AP Biology curriculum. However, what is not yet clear to the student is why this information is important in today's world. If we truly wish students to internalize the scientific persona, then it is exceedingly important to open the door to their creative use of the information in a new context. In addition, there are other sections of the AP curriculum that build upon this conceptual framework. How to extend the module to provide for independent student work on an advanced topic will be covered in a follow-up article.

Appendix 1: Directions for sketching and viewing one amino acid in ChemSketch.

On the top left of ChemSketch, one chooses Structure. On the right vertical column is a tab for COOH. Select that and then click once in the drawing window. In the left vertical panel, select the C (carbon). On the page, click on the C of the COOH group, drag it a short distance and release. Click on that newly created CH3 (alpha C), drag and release. Repeat this to add another CH3 to that alpha C. In the left vertical panel, select N. Click on one of those CH3 groups. One now has the amino acid alanine. Under tools, select clean structure. This produces a professional structure (e.g., all the bonds have the same lengths). Next, select the icon for 3D viewer. A new window opens. On the top tool bar, students can select sticks, ball-and-sticks or even space-filling models for their amino acids. Finally, if you prefer to cut and paste amino acid structures, click on templates, then template window. In the new window, please click on amino acids. These amino acid structures can be copied and pasted into a sheet.

Hot Atom Chemistry

[This brief article by Willard F. Libby appeared in the March 1950 issue of *Scientific American*.]

One of the first things a beginning chemistry student learns is that the chemical behavior of an atom depends solely on the electrons circulating around the nucleus, and not at all on the nucleus itself. In fact, the classical definition of isotopes states that all the isotopes of a given element are identical in chemical activity, even though the nuclei are different. Like all generalizations, even this one has a little bit of falsehood in it. The truth is that the chemical behavior of an atom may be strongly influenced by events in the nucleus, if the nucleus is radioactive. The bizarre chemical effects sometimes produced by radioactive atoms have given rise to a fascinating new branch of investigation known as hot atom chemistry.

Unusual chemical reactions among hot atoms were noticed soon after the discovery of radioactivity. The serious study of hot atom chemistry began as early as 1934, when Leo Szilard and T.A. Chalmers in England devised a method, known as the Szilard-Chalmers process, for utilizing such reactions to obtain concentrated samples of certain radioactive compounds for research purposes. But not until the end of the recent war, when chemists began to work with large amounts of radioactive materials, did the subject begin to attract wide interest. Since the war, reports of investigations in the intriguing field have come from laboratories in all the leading scientific countries of the world.

The particular set of reactions we shall consider is the behavior of radioactive iodine in the compound ethyl iodide—CH_3CH_2I. We begin with an ordinary liquid sample of the compound and transform some of the iodine atoms in it to a radioactive variety by irradiating them with neutrons from a chain-reacting pile or a cyclotron. Neutrons have no chemical properties, since they consist of pure nuclear matter with no associated external electrons. Because they have no external electrons, and are themselves electrically neutral, their penetrating power is amazing. They readily proceed through several inches of solid material until they chance to interact with some of the tiny atomic nuclei in their path.

Suppose, then, we expose a bottle of liquid ethyl iodide to a source of neutrons. The neutrons penetrate the glass, and a certain proportion of them are captured by the iodine atoms. When the nucleus of a normal iodine atom, I-127, takes in a neutron, it is transformed into the radioactive isotope I-128. This new species is extremely unstable: in much less than a millionth of a millionth of a second it emits a gamma ray of huge energy—several million electron volts. After giving off this tremendous energy, the I-128 atom is reduced to a lower state of excitation. It is still unstable; the atom continues to decay, and gradually, with a half-life of 25 minutes, the I-128 atoms degenerate into xenon-128 by emitting beta particles. The emission of this energy gives the I-128 atom in the ethyl iodide molecule a large recoil energy, just as the firing of a bullet from a gun makes the gun recoil. The atom's recoil energy is calculated to be some 200 million electron volts. Now the chemical energy with which the iodine atom is bound in the ethyl iodide molecule is only about three or four electron volts. The energy of recoil is so much greater that the strength of the chemical bond that every I-128 atom is ejected from its molecule with considerable force. Hot atom chemistry is concerned with the unusual chemical reactions that these high-velocity iodine atoms undergo after they are expelled from the molecule. Since the I-128 atoms are radioactive, it is relatively easy to trace them through their subsequent activities.

To what use can hot atom chemistry be put? One of the obvious uses is the preparation of extremely concentrated sources of radioactivity. This technique should be of assistance in many purposes for which radioactive material is used, notably in biology. When a radioactive isotope is injected into the body, either as a tracer or in a treatment for a disease, it is often essential that the amount of material injected be held to a minimum, in order to avoid disturbance of the normal constitution of the blood or the normal metabolism of the body.

Magic Metals

[These excerpts are from a commentary of the same title by Saleem H. Ali that appeared in the January 2014 issue of *Scientific American*.]

There's one problem with the silicon age: its magic depends on elements that are far scarcer than beach sand. Some aren't merely in limited supply: many people have never heard of them. And yet those elements have become essential to the green economy. Alien-sounding elements such as yttrium, neodymium, europium, terbium and dysprosium are key components of energy-saving lights, powerful permanent magnets and other technologies. And then there are gallium, indium and tellurium, which create the thin-filmed photovoltaics needed in solar panels. The U.S. Department of Energy now counts those first five elements as "critical materials" crucial to new technology but whose supply is at risk of disruption. The department's experts are closely monitoring global production of the last three and likewise the lithium that provides batteries for pocket flashlights and hybrid cars.

…The appropriation made it through Congress almost certainly because of legislators' fear of China's dominance in many critical elements and Bolivia's ambition to become "the Saudi Arabia of lithium."

The worries are probably inevitable. China—historically a prickly partner at best to the U.S.—effectively has much of the world's critical-materials market at its mercy. Take the rare earth elements neodymium, europium, terbium and dysprosium. Despite their name, rare earths are many times more common than gold or platinum and can be found in deposits around the world. In recent years, however, cheap labor and lax environmental regulation have enabled China to corner the global market, mining and refining well over 90 percent of rare earths.…

There's more at stake here than fancy gadgets for the rich. The point of critical materials is to use energy more efficiently. One fifth of the world still lives without access to clean, affordable electricity, a problem that unimpeded supplies of rare earths and lithium could eventually remedy. The hard part will be to prevent old international feuds from getting in the way of that goal.…

…Narrow national interests and rivalries can only obstruct that process, ultimately leaving us all just that much poorer. The need for critical materials should catalyze international cooperation. After all, those materials can enlighten the world—literally.

The Reality of Molecules

[This brief article by Theodor Svedberg appeared in the February 1913 issue of *Scientific American*.]

Anyone consulting a handbook of chemistry or physics written toward the end of the nineteenth century, to gain information regarding molecules, would in many cases have met with rather skeptical statements as to their real existence. Some authors went so far as to deny that it would ever be possible to decide the question experimentally. And now, after one short decade, how the aspect of things is changed! The existence of molecules may today be considered as firmly established. The cause of this radical change of front must be sought in the experimental investigations of our still youthful twentieth century. Rutherford's brilliant investigation on α-rays, and several researches on suspensions of small particles in liquids and gases, furnish the experimental substantiation of the atomistic conception of matter.

The modern proof of the existence of molecules is based in part upon phenomena which give us a direct insight into the discontinuous (discrete) structure of matter, and in part upon the "working model" of the kinetic theory furnished us in colloidal solutions. These last have been shown to differ from "true" solutions only in that the particles of dissolved substances are very much larger in the case of colloids. In all respects they behave like true solutions, and follow the same laws as the latter. And, thirdly, the recent direct proof of the existence of indivisible elementary electric charges enable us to draw conclusions regarding the atomic structure of ponderable matter.

Among the first-mentioned class of proofs is Rutherford's great discovery (1902-1909) that many radioactive substance emit small particles which, after losing their velocity, as for instance by impact against the walls of a containing vessel, display the properties of helium gas. In this way it has been proved experimentally that helium is built up of small discrete particles, molecules. In fact, Rutherford was able actually to count the number of particles or helium molecules contained in one cubic centimeter of helium gas at 0 degrees Centigrade and one atmosphere pressure (1908).

The second class of proofs of the existence of molecules comprises a number of researches on the changes of concentration with level which is observed in colloidal suspensions, and on the related phenomena of diffusion, Brownian motion, and light absorption in all such systems.

Lastly, modern investigations of the conduction of electricity through gases, and of the so-called β rays, have shown conclusively that electric charges, like matter, are of atomic nature, i.e., composed of ultimate elementary charged particles, whose mass is only about 1/700 of a hydrogen atom. Quite recently Millikan and Regener have succeeded by entirely different methods in isolating an electron and studying it directly.

We see, then, that the scientific work of the past decade has brought most convincing proof of the existence of molecules. Not only is the atomic structure of matter demonstrated beyond reasonable doubt, but means have actually been found to study an individual atom. We can now directly *count* and *weigh* the atoms. What skeptic could ask for more?

Trust and Innovation

[These excerpts are from an editorial by Joan Richardson that appeared in the November 2013 issue of *Phi Delta Kappan*.]

…the importance of relationships in spreading innovation in schools. In fact, it's one of those concepts that seems so simple, so obvious, that I wonder why we even have to talk about this.

Quite simply, most of us are more likely to listen to an idea from someone we know and respect. When some faraway person, especially someone in authority, tries to tell us what to do, that just rubs us the wrong way. *They don't know my kids! They haven't worked in this district!*

The out-of-town expert with the briefcase is much less likely to win over a teacher to a new idea than a teacher down the hall….

Young educators, in particular, are sending this message loudly enough that even the older brethren should be able to hear it: They do not trust traditional forms of professional development. What they trust are relationships they develop themselves, even if they're with educators they've never met in person. They don't want to sit in a room and be lectured. They want to learn from someone who is more like them than the traditional presenter at the front of the room.

All of this works, at least in part, because when we speak to someone one-to-one, we drop all the research babble and education jargon, and we just speak from the heart. We look into someone's eyes, and we know instantly whether they're getting the message, and we adapt. We use precise language. We use examples that they can understand.

How differently would schools and districts operate if we would simply encourage teachers and principals to share what they know with each other? How much knowledge are we wasting? How many good ideas never spread beyond one classroom or one school because we just won't make the time to allow teachers to talk with and learn from each other?

Within any given school or district reside the wisdom of dozens and hundreds of smart educators who are learning from their work every day. They want to share what they know. Listen to them. And learn.

...there's so much they don't know. And not knowing things makes them know lots of other things grownups can't know. That sounds confusing and it is. But look at it this way. Every time you teach a kid something, you teach him a hundred things that are impossible because that one thing is so. By the time we grow up, our world is so hedged around by impossibilities that it's a wonder we ever try anything new.

—Zenna Henderson
"Come On, Wagon!"
The Anything Box

Network of Educators in Science and Technology
20 Ames Street, Bldg E15-301
Cambridge, MA 02142 USA

Forwarding and Return Postage Guaranteed
Address Correction Requested

4/14

Opportunities for NEST members are outlined on the NEST website—http://web.mit.edu/scienceprogram/nest. They include options to attend the annual NEST Reunion at MIT and submit nominations for Student Awards and the Teacher of the Year Award, which celebrates educators who do extraordinary work promoting science and technology in their communities. Nominations, reunion registration fees, annual dues payments, and donations can be sent to the address below, to the attention of Emily Martin, SEPT Coordinator. Or, please contact us by email (sept@mit.edu) to receive announcements sent via the Network of Educators in Science and Technology Discussion List (NESTD-L).

Emily Martin, SEPT Coordinator
Massachusetts Institute of Technology
Network of Educators in Science and Technology
20 Ames Street, Bldg E15-301
Cambridge, MA 02142 USA

The Network of Educators in Science and Technology (NEST) is a member driven organization dedicated to the promotion of literacy in science, technology, engineering, and math.
http://web.mit.edu/scienceprogram/nest

NEST Newsletter Vol. 26, No. 1
Editor: Avi Ornstein
Designer: Satya Picard

The deadline for publication in the next issue is September 1. We welcome your contributions. Please send articles to:

ornstein@alum.mit.edu
or
Avi Ornstein
207 Garry Drive
New Britain, CT 06052