

**AC 2010-151: THE NIST SUMMER INSTITUTE FOR MIDDLE SCHOOL  
SCIENCE TEACHERS: TRANSLATING NIST RESEARCH INTO ACTIVITIES  
FOR THE MIDDLE SCHOOL CLASSROOM**

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# **The NIST Summer Institute for Middle School Science Teachers: Translating NIST Research into Activities for the Middle School Classroom**

## Abstract

The National Institute of Standards and Technology (NIST) Summer Institute for Middle School Science Teachers, a collaboration between NIST and local school districts, is a two-week workshop designed to support middle school science teachers through a combination of hands-on activities, lectures, tours, and visits with scientists and engineers in their laboratories.

Throughout the workshop teachers are provided with in-depth material on topics in the middle school curriculum taught by NIST scientists and also provided resources and instructional tools to teach that material in the classroom.

The NIST Summer Institute is designed to increase the teachers' understanding of the subjects they teach, provide materials and resources to implement what they have learned at NIST in the classroom, rekindle their enthusiasm for science, and provide a network of scientists and engineers at NIST available for consultation. Teachers finish the NIST Summer Institute with a wealth of knowledge about core topics such as forensics and materials science, and materials to integrate these topics into their existing curriculum.

To introduce them to scientific research teachers are given the opportunity to spend an hour each week one-on-one with a scientist or engineer in his/her lab, learning about research and conversing about topics of interest. Undergraduate fellows doing research at NIST are also incorporated into the NIST Summer Institute, and are available for one-on-one visits and as members of a panel discussion on middle school science education. The undergraduates are questioned about their middle school science experiences, and for suggestions on ways to encourage interest in science, technology, engineering, and math(STEM) careers. Other informal occasions are made available for NIST scientists and engineers, undergraduate research fellows, and NIST Summer Institute teachers to meet and socialize with the goal of building networks for future interactions.

Teacher participants in the NIST Summer Institute are invited back to NIST during the school year for ‘Science Afternoons at NIST’ where the focus is on one chosen topic with an interactive seminar and activities. Previous Science Afternoons have focused on such topics as designing buildings to resist earthquakes, weather, and nanomagnetism. As during the NIST Summer Institute, teachers leave the Science Afternoons with a wealth of information about the focus topic and materials and resources for teaching the topic and leading activities in the classroom.

In compliance with the Academic Competitiveness Council’s requirements for assessment the Summer Institute is judged by an independent contractor with pre-workshop surveys, follow-up focus group interviews, classroom observations, and surveys over the year following workshop participation. Teachers have been enthusiastic about the quality of the workshop and the support from NIST available for their educational endeavors. Their input has been used to make modifications each year so that teachers get as much as possible out of the workshop.

While not a teaching institution but a research institute focused on meeting the measurement science needs of the nation, NIST has a wealth of resources for the education community. The NIST Summer Institute for Middle School Science Teachers is one way of sharing these resources and building partnerships between local middle school teachers and NIST scientists.

### Introduction and Background

As a non-regulatory agency of the Department of Commerce, NIST promotes U.S. economic growth by working with industry to develop and apply technology, measurements and standards. Located in Gaithersburg, MD, a suburb of Washington, D.C., NIST scientists conduct research in a wide variety of the physical and engineering sciences. NIST has laboratories in chemistry, physics, electronics and electrical engineering, building and fire research, manufacturing engineering, materials science and engineering, information technology, and neutron research. The work NIST does by providing measurement methods, tools, data, and technology underpins innovative technological advances throughout all scientific endeavors.

As a scientific research institution, NIST is dependent on a supply of well-educated scientists, engineers, and mathematicians. A recent report from the National Academy of Sciences, *Rising above the Gathering Storm*, noted the declining numbers of American students pursuing STEM careers, and the urgent need to reverse this trend, if a subsequent drop in U.S. economic development is to be averted.<sup>1</sup> Additionally, a report by the Academic Competitiveness Council details goals and metrics for encouraging more American students to study STEM careers.<sup>2</sup>

The NIST Summer Institute for Middle School Science Teachers evolved from an idea of Dr. Hratch Semerjian, former NIST Chief Scientist, who wanted to support local educators by sharing NIST resources as a means to encourage more students to pursue STEM careers. Semerjian envisioned a program aimed at middle school teachers as key in contributing to a pipeline of students that might eventually work at NIST or other research laboratories. For the greatest impact Semerjian chose to focus on teachers since they can be a critical factor in encouraging their students to pursue STEM careers, and have a potentially significant impact on ~150 students daily.

Since the program began it became apparent to us that many middle school science teachers do not have degrees in science and may have been trained as elementary teachers, thus are eager to improve and extend their scientific knowledge and understanding. NIST scientists and engineers, as members of the community they live in, are usually eager to participate in educational outreach activities and welcome the opportunity to share what they do in a meaningful way with local educators.

### Components of the NIST Summer Institute

The NIST Summer Institute is designed to support teachers in teaching science and math at the middle school level. Initially, a study of the middle school curriculum, both Maryland state and local school districts, grades 6-8 was carried out, looking in particular for topics that overlap with research in progress at NIST. NIST, although historically a physical science research institute that focuses on measurement science and technology related to physics, chemistry, and associated engineering and mathematics, is increasingly also involved in research involving

biology and biotechnology related fields. This wide range of research provides multiple opportunities for overlap with the middle school curriculum, including forensics, chemical reactions, materials science, magnetism, and earthquakes, as shown in Figure 1, the 2009 schedule.

When considering the topics to be taught in the NIST Summer Institute, the focus and purpose of NIST is also kept in mind. NIST, as the premier U.S. measurement science, or metrology, research laboratory has much to teach regarding the role of measurement science and its importance. The NIST Summer Institute begins with an overview of NIST and a focus on metrology and its importance in everyday life. These lessons include tours of the NIST museum with exhibits of NIST work in the hundred years of its existence and replicas of original Système International (SI) units such as a meter stick and a kilogram. Teachers are also given a 'NIST in Your Community' tour in which they are introduced to the all-encompassing use of NIST measurement science in their everyday lives, from the food they eat, to telling time, to visits to the doctor. The afternoon of the first day is spent in part with NIST statisticians and an activity designed to teach the unfamiliar concept of measurement uncertainty. "Which measurement is correct?" teachers are asked, and "How do you know?" Throughout the following days the critical importance of measurement science is returned to over and over, as teachers learn about various aspects of research and metrological challenges across NIST.

The NIST Summer Institute is designed to support middle school science teachers by improving teachers' content knowledge. NIST scientists and engineers, who are experts in their field, are brought in to teach and update the teachers on the latest developments and technology. They share how the research is conducted in the real world and the results utilized to bring improvements. The key to success in this component is finding NIST staff that can teach in an engaging and understandable way at or slightly above the level of the teachers. Usually these scientists self-select in that they often are involved in other NIST educational outreach activities such as 'Adventures in Science' or 'Take Our Daughters and Sons to Work Day'. When approached to participate in the NIST Summer Institute most are very willing to be involved and already have an idea of what to do and just need guidance on the material of interest. The lectures are designed to be interactive and often are, but the interactivity depends on the

personality of the scientist, the material being taught, and the comfort level of the teachers; as the workshop progresses through its two weeks the level of interactivity typically increases. A back-and-forth exchange between the teachers and the scientists is encouraged both to increase the understanding of the teachers and to increase the understanding of the scientist as to the background, understanding, and interest of the teachers. As any good teacher knows, one becomes a better teacher through the act of teaching, and though interacting with one's students; scientists at NIST are no exception to this.

Many of the scientists involved in the NIST Summer Institute also have designed or found activities and materials that correlate with the topic they teach. For example an engineer in NIST's Building and Fire Research Laboratory who had been working with the 'Take Our Daughters and Sons to Work' program for several years was requested to teach about earthquake resistant buildings to the teachers, initially at a 'Science Afternoon at NIST' follow up to the NIST Summer Institute. The staff member had designed and had built a series of props that were a very effective part of his presentation. Although the props could not be classified as *activities* that students could be directly involved in, their use made for a more effective presentation of fundamental aspects of earthquake propagation including resonance, wave motion, and the build-up of energy as tectonic plates shift. In a twist on the use of hands-on activities, after the lecture was given using these props, the teachers were provided the opportunity to build these props for themselves, and encouraged to practice their use. See Figure 2 for a picture of a teacher leaving for the day with her arms full of props she has just completed building.

A side note: since the NIST Summer Institute is open to all middle school teachers and earthquakes are typically taught in only one grade, there was initial concern that many of the teachers in the Institute would find the topic and materials on earthquakes of little use. Not so, the teachers said. In some cases, such as the reverse pendulum model, the materials would be useful in teaching wave motion, a topic taught in other grades, and the principles taught as applied to buildings could be extrapolated to other topics such as light and the motion of molecules. Additionally, many teachers realize that with curriculum changes and shifts of teachers from teaching one grade to another grade that they may be teaching about earthquakes at some point, even if they are not presently. Another alternative implemented by teachers has

been to share the material and props with others at the school that may be teaching that particular topic. All of these possibilities fulfill the goal of seeing the materials from NIST in use in the classroom, inspiring students to pursue STEM careers.

In some cases NIST Summer Institute staff design or discover teaching tools for hands-on exploration of the subject, and work with the NIST scientists who are the subject experts to incorporate them in the Institute. For example, in the day spent on forensics one element is a visit to a lab involved in human identification through the use of deoxyribonucleic acid (DNA) short tandem repeats. Development of NIST Standard Reference Materials, and standard protocols for human identification has made possible close to unequivocal identification of humans in paternity cases to criminal cases to identification of the September 11, 2001 victims. During the lab visits and lecture, emphasis is placed on the foundation of measurement science that makes these identifications possible. In the lab tour and demonstration the NIST scientist explains how DNA is used for identification and does a demonstration electrophoresis using a ‘flash gel’ that separates DNA in seven minutes, literally as the audience watches. Seeing the separation right before ones eyes is a powerful lesson that is expanded upon by the lecture, and then by the opportunity the teachers have to carry out electrophoresis on their own.

Back in the classroom, teachers are introduced to the extraction of DNA from a strawberry using easily available components including detergent, salt, funnels, and test tubes, and then separation of the DNA by the same technique just observed in the lab but modified for use in a middle school classroom. In an activity that all the teachers can participate in both as a learning experience and as practice for leading the activity in the classroom, electrophoresis kits from a biology educational supplier that are safe and effective for teaching about DNA separation are used. Typically in the group of workshop participants one or two of the teachers have previous experience with electrophoresis and are willing to lead the others in the activity, sharing their understanding and technique.

In conjunction with its name and mission, the National Institute of Standards and *Technology*, the NIST Summer Institute includes a significant advanced technology component through the utilization of an interface and sensors. As most teachers have experienced, the purpose of some

experiments is obscured by the difficulty of making accurate measurements using the tools available. As a case in point, if students are using thermometers and have difficulty reading the meniscus, valuable data and learning opportunities may be lost, and the lesson, for example that the addition of salt to water decreases the freezing point of a solution, may be masked by measurement error. The use of interfaces such as the VernierLabQuest makes possible easy, quick measurements and data analysis enabling discovery of what is intended. The NIST Summer Institute provides to each teacher a LabQuest and sensors for measuring temperature, magnetic field strength, pH, motion, force, gas pressure, heart rate, and electrical conductivity. The LabQuest is currently integrated into several of the NIST Summer Institute activities including thermometry and diffraction and there is an ongoing effort to encourage scientists to develop activities using the LabQuest and probes, with loans made to scientists for this purpose.

Scientists are eager to investigate use of the LabQuest and probes for their own edification and also because as befits people in their career field they enjoy learning new things. The NIST scientists and engineers who participate in the NIST Summer Institute are also eager to share how they do their research with the teachers, and a call goes out every spring for volunteers to meet with the teachers one-on-one and explain how their research is accomplished. Scientists who participate in the hour-long one-on-one visits with a teacher spend the time showing off their lab, going over the story of their career at NIST, and/or discussing scientific endeavors of interest to both the teacher and the scientist. The goal for this time together is set as an opportunity for the teachers to see how scientific research is done. Although some of the middle school science teachers have science degrees, few have ever done research or even been in a research lab. The tours and the visits with the scientists are designed to provide a window into scientific research as performed at NIST.

To a middle school teacher some of the NIST scientists, most with PhDs and as experts in their fields, can be quite intimidating. Not so the interactions with the undergraduate students whose time at NIST overlaps with the NIST Summer Institute. The NIST Summer Undergraduate Research Fellows, or SURF students, are at NIST for 11 weeks during the summer performing research with NIST scientists that culminates with a symposium and presentations of their work in early August each year. Since the SURF students are relatively close in age to the students of



the teachers, they are a valuable resource as to what worked and what did not to encourage them to study science and engineering. Additionally, since SURF students are involved in research with NIST scientists they are often in the process of learning about how science is done and are readily able and willing to explain what they are learning. SURF students who volunteer to meet one-on-one with the teachers are usually easily able to explain their project, demonstrate some experiments, and show off their labs in ways some of the NIST scientists have long ago moved beyond.

When NIST staff (i.e. scientists, engineers, mathematicians, statisticians, etc.) and SURF students volunteer to participate in the NIST Summer Institute one-on-one visits they are asked to provide a short biography and summary of their work at NIST. This information is compiled and provided to the teachers who make a selection of the top three staff they would like to visit with for an hour. Teachers are then matched with a NIST staff member or SURF student. Two opportunities for the scientist one-on-one visits are provided, one each week. Initially, the scientist visits were longer, and were originally envisioned as lasting a morning or afternoon, but based on feedback from both the staff participants and teachers the current length of about an hour seems to be just long enough but not too long. One outgrowth of the one-on-one visits with scientists has been the development of a Research Experience for Teachers (RET) program based on the expressed desires of some of the teachers to spend the summer doing research just like the SURF students. Although not yet implemented, NIST hopes to be able to provide a pilot RET program for teachers within the next couple of years. Such a program would enable local teachers to participate in NIST research, learning for themselves how research is carried out.

SURF students are also asked if they would be interested in participating in a panel discussion on the middle school science experience. Volunteers come forward, often with particularly good or bad middle school science experiences that they want to share, and five are selected. During the panel discussion questions are raised regarding how to most effectively encourage students to continue their interest in science and to pursue STEM careers. While this group is self-selected, the SURF students being STEM majors in college, it is interesting and instructional to learn the impact of the educational system on the students. In many cases the role of teachers in middle school and/or high school were pivotal in encouraging the students to pursue STEM careers,

either out of the obvious interest of the teachers in the subject they teach or the way they teach that ignites the interest and curiosity of their students. The panel discussion is designed to encourage the teachers to consider the effect their teaching styles and habits have on their students and to inspire them to reach out to more students.

To facilitate more scientist/engineer/SURF student/teacher interaction social events and opportunities for informal interactions are scheduled throughout the NIST Summer Institute in the belief that more quality interactions are the result of increased exposure with the final result being a network of relationships between NIST staff and the teachers. The teachers can call upon these relationships in future times of need, for example, for science fair project help, as a possible source of consumables such as liquid nitrogen, or for more in-depth information regarding a particular topic of interest. The goal is to create a dynamic and on-going structure that supports the middle school teachers throughout their school year.

Each year the NIST Summer Institute has been modified to better meet teachers' needs and to coordinate with new research at NIST. For example, the discovery of a collaboration between NIST and a local high school on the use of growing algae for biofuels led to the exploration of possible connections to the middle school curriculum. Subsequently, a unit on photosynthesis based on growing algae in a bioreactor and monitoring changes in carbon dioxide and oxygen levels with sensors was added to the Institute curriculum. The high school students were invited on the first Wednesday of the two-week workshop to teach the teachers about the biofuels project and to get the teachers started in growing their own algae in a bioreactor. Over the next ten days of the NIST Summer Institute as the algae grew the teachers were able to monitor algal growth in their biochambers. This new addition to the NIST Summer Institute culminated in a tour of the biofuels labs at NIST and experiments converting oil to biodiesel in a simulation of how the students hope to someday convert the lipids extracted from algae to biodiesel. The tour and experiments were held on the last day of the NIST Summer Institute and all previous participants were invited to return and participate. Returning teachers were also given the materials, equipment, and information to carry out the algae growth and biofuels experiments at their home schools.

After the NIST Summer Institute ends and teachers return to their home schools, plans are made at NIST to invite the teachers back for Science Afternoons at NIST. All teachers who are past participants in the NIST Summer Institutes are invited so the attendees are a unique new mix of teachers, all of who can learn from each other. Science Afternoons have evolved to focus on a single scientific topic, one that may not be of interest to all the teachers but may be of high interest to some. The afternoons run from 4:00PM-7:00PM with the first hour set aside for arrival and teacher socializing and sharing. Teachers are encouraged to bring material they would like to share regarding the topic of the afternoon and time is provided for this forum. Having this time enables this unique mix of teachers to become acquainted and fosters new relationships and interactions.

The format of the following two hours is similar to that of the NIST Summer Institute with an interactive lecture, demos, and activities. Past topics include earthquake proof buildings (the success of the topic as a Science Afternoon encouraged us to integrate the topic into the full Summer Institute the following year), weather and pressure, spectroscopy, and nanomagnetism. As an added incentive to attend teachers are often given new sensors for the LabQuest and/or materials and equipment to implement new activities and experiments in their classroom. For example, for the “weather and pressure” Science Afternoon teachers were given a barometer that interfaces with the LabQuest and did experiments measuring changes in barometric pressure as they ascended and descended the nine floors in the main administration building at NIST. Participation in the Science Afternoons at NIST are intended to foster relationships between NIST staff and teachers, expand upon teacher knowledge and understanding of one particular topic, and to boost excitement and enthusiasm about a particular scientific topic. Providing new experiences, new activities that can be easily implemented into the classroom, and interaction with fellow teachers intent on similar actions has proven successful for all involved. In addition, both the NIST Summer Institute itself and the follow up ‘Science Afternoons at NIST’ give the participating teachers the opportunity of building a network of contacts among the NIST scientists and engineers that can be used for future interactions.

Assessment of the NIST Summer Institute

After the completion of the NIST Summer Institute, teachers return to their schools with increased knowledge about their subject matter, ideas for activities, materials, and equipment to implement these activities, and heightened enthusiasm about engineering and science. Based on their volunteered comments and on the evaluations of the workshop, teachers leave the Institute with increased enthusiasm about science and their teaching. Assessment of the effectiveness of the NIST Summer Institute is an important component in assuring that we remain true to our purpose, and is carried out both informally throughout the two weeks of the workshop and formally by an independent contractor. Assessing the effectiveness of a workshop such as this is difficult and necessarily subjective. It has not been possible to have a control group for comparison, and many of the goals of the Institute such as increasing teacher enthusiasm for the science they teach, are difficult to quantitatively and objectively assess. That being said, efforts are made to assess what has been done and to learn from the results.

Before the workshop begins a survey is sent inquiring about the teachers' background, education, experience, grades taught, self-perceived needs, and scientific interests. This information is used as guidance to set the level of the Institute, and the need for focus on particular topics. Based on the different levels of the teacher participants, plans are made to encourage the more highly educated and experienced teachers to work with the less experienced teachers. For example, one summer several of the teachers came to the Institute with prior experience in gel electrophoresis and so were asked if they would be willing and interested in participating in the novice teachers' exploration of the activity. One teacher was inspired to lead this experiment and used the opportunity to share his previous experiences, including invaluable teaching tips and possible pitfalls. He guided the participants in learning how to do electrophoresis and prepare them to teach electrophoresis on their own. Although it is usually not possible to find self-selected guides for most components of the Institute, efforts are continuously made to foster community among the teachers and to encourage them to learn from each other. Knowledge of the backgrounds of the teachers from surveys and from visiting with them and learning about other experiences they have had is used to enrich the workshop for all teachers by encouraging sharing and active participation by all, no matter their experience level or educational background.

During each week of the NIST Summer Institute the teachers carry a single-page assessment with the names of all the activities, from lectures and lab tours to ice cream socials and visits with scientists one-on-one (see Figure 3 for a completed version from 2009). After each activity the teachers are encouraged to rate the activity in terms of usefulness to them, and make comments. These assessments are especially valuable in the follow up visits with the NIST scientists and presenters in which the presentations are reviewed and plans made for improvements. These assessments highlight one of the disadvantages of the Institute since the participants are from all three middle school grades, and what is of use to one teacher may not be of immediate use to another teacher. The subjectivity of the assessments is also evident when every teacher ranks a lecture by one of NIST Nobel prizewinners, a charismatic speaker with multiple demonstrations, on the cooling and trapping of atoms, with a “1”, or as very useful! This effect highlights the importance of presentation skills and points out that the evaluations in some aspects are “popularity contests,” and their acknowledged value is not always directly related to what is written. As for the popularity of the Nobel prizewinning speaker, the enthusiasm he inspired was well worth the time spent, even if the topic area was of little use to most of the teachers. Of course, since one of the goals of the NIST Summer Institute is to expand the understanding of the teachers about science in general high rankings on such esoteric topics are taken as success.

During the two weeks of the NIST Summer Institute staff, from the independent assessment contractor attend several activities and make observations, designed to see how effective the presentations are and the level of engagement of the teachers. On the last day of the Institute the teachers are broken into focus groups by grade level and interviewed. These focus groups yield immediate feedback regarding aspects of the Institute that were very successful or less so, as judged by the teachers soon after participation. The focus groups also provide a forum for discussions centered on exploring ways to improve future NIST Summer Institutes and possible topics for return visits to NIST during the school year, the Science Afternoons at NIST.

One topic that surfaced with some urgency this last summer, both from the weekly assessment sheet and the focus groups was the need for additional training with the LabQuest and sensors. Teachers are given time during the first week to explore the use of the LabQuest and to use it in

several different experiments of their choice but specific guided instruction had been minimal. In a happy coincidence several high school students who had been loaned LabQuests and oxygen and carbon dioxide sensors for the project involving the growth of algae for biofuel were available and enlisted as teachers during that first week. However, it quickly became evident that some of the teachers could have benefited from additional specific guided instruction. In future Summer Institutes more time will be devoted to teaching the basics of LabQuest use so that teachers are more familiar with it and its capabilities. As with any classroom the range of abilities with different concepts including advanced technology such as the LabQuest and sensors varies and continuing efforts are made to meet the needs of all the teachers. An additional way to meet this need may be to have a Science Afternoon at NIST focused specifically on the use of the LabQuest in the classroom, and to provide additional teacher training on its use perhaps matching proficient teachers with those who request guidance.

In the year following their participation in the NIST Summer Institute several teachers are selected for classroom observation by contractor assessment staff. The observations are targeted at the use of NIST material or activities, chosen by the teachers. Topics observed in the past include chromatography and the metric system. From these observations, from casual conversations with the teachers, and from surveys of the teachers we have learned the importance of providing classroom-ready material, including activities, equipment, and consumables. Although some teachers are motivated and creative enough to modify the NIST activity write-ups for their own use, many teachers are too busy to make modifications and will only use the material if it is essentially ready to be used in the classroom. Since coming to this awareness, future Summer Institutes will benefit from modified materials and from taking advantage of modifications from previous teachers. This will necessarily be an on-going process due to the dynamic structure of the NIST Summer Institutewith the continuing incorporation of new material and modification of previously used material.

All the assessments associated with the NIST Summer Institute for Middle School Science Teachers are viewed as opportunities for learning and improvement. Although the tools are imperfect and necessarily subjective, the variety used provides different forms and kinds of feedback, all of which is valuable and taken into account when planning future interactions.

## Future Plans

During the past three years the NIST Summer Institute has evolved to a steady state of interactive lectures, activities translating NIST research into the classroom, tours of NIST labs, and visits with NIST researchers. Modifications such as changes in topics and format to include past participants have been made to enable greater impact and more overlap with teacher interests and needs; additional changes will be made as opportunities arise and the need is seen. Future changes envisioned include encouraging a dynamic learning community with on-going interactive access to NIST material through a NIST-supported social media portal such as a wiki that teachers could post activities, ask questions, and discuss concerns. This is not a new idea; a wiki was set up by one of the participants during the second year of the NIST Summer Institute and used by many participants for about six months. Innovative and forward thinking will be required to maintain and motivate teachers, some of whom are adverse to the addition of what they see as a new claim on their time, on a future wiki. Another idea to pursue in a more organized and focused way is the use of high school students to actively work with the program. Last year, the third year of the program, a high school volunteer took part in the Summer Institute as an honorary participant, office assistant, and direct partner in the program, taking part in the activities alongside the teachers. Gradually, she took on more duties including writing help pages for the LabQuest and sensors, and eventually designed a slide show highlighting teacher activities during the two weeks. The incorporation of students as resources, especially for teaching the use of technology, is envisioned to increase the teacher comfort level with the LabQuest while providing more one-on-one training. Remaining true to the purpose of the NIST Summer Institute will enable future changes as yet unseen but sure to make improvements and have an impact.

## Conclusion

While not a teaching institution but a research institute focused on meeting the measurement science needs of the nation, NIST has a wealth of resources for the education community. The

NIST Summer Institute for Middle School Science Teachers is one way of sharing these resources and building partnerships between local middle school teachers and NIST scientists.

The NIST Summer Institute provides an opportunity for NIST staff to reach out to the local educational community, educational outreach, yes, but more than that: a chance for NIST to give back to the community that includes the families of the NIST staff. Begun with the original goal of increasing the pool of NIST scientists and engineers through encouraging student interest in STEM careers, the NIST Summer Institute has become an occasion for two-way interactions between the local educational community and NIST. NIST staff learn more about middle school education and educational needs and how to foster student interest in STEM careers, and those in the educational establishment take advantage of the vast wealth of scientific and engineering resources at NIST to improve their teaching and inspire future generations of American scientists and engineers. The NIST Summer Institute provides a bridge between the cutting edge research done at NIST and the local educational community bringing two disparate communities together with the goal of supporting middle school science and math teachers.

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#### References

1. Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2007) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. The National Academies Press. [http://www.nap.edu/catalog.php?record\\_id=11463#toc](http://www.nap.edu/catalog.php?record_id=11463#toc). Accessed 2 Jan 2010
2. U.S. Department of Education (2007) Report of the Academic Competitiveness Council. <http://www.ed.gov/about/inits/ed/competitiveness/acc-mathscience/report.pdf>. Accessed 2 Jan 2010



date/ time	Monday, July 6	Tuesday, July 7	Wednesday, July 8	Thursday, July 9	Friday, July 10	Monday, July 13	Tuesday, July 14	Wednesday, July 15	Thursday, July 16	Friday, July 17
9-10	<b>Orientation</b> -NIST Overview (9-9:45) <b>Workshop Overview</b> -Who we are as a group (9:45-10:45)	<b>Metrology 2: Metrics Jeopardy</b> (10:1/B11, 9:05-10:15)  <b>-Weights and Measures Overview</b> -Activities (10:30-12)	*LabQuests, probes, lab manuals, software distributed 9-9:30 -goals of day: try out LabQuests and sensors using <u>MiddleSchool Lab Manual</u> <b>Bioreactor Set-Up</b> 11AM (9-12) Visit to SEBA, NIST Store 11:55	<b>Separations 2: Solving Crimes with Science</b> -Lecture (9-10)  <b>-Forensic Science Classroom Experiments</b> (10-11)  <b>-DNA Extraction Activity</b> (11-12)	<b>Materials Science: -pH of Water</b> (9-10:30)  <b>-Cement Activity</b> (11-12)	<b>Separations 3: The NIST Center for Neutron Research (NCNR) Production of Neutrons</b>  <b>Crystal Growth Lab</b>  <b>Tour Part I</b> (9-12)	<b>Building Science: Designing Bldgs to Resist Earthquakes</b> (9-11:45)  <b>Picture under Newton Apple Tree</b> 11-45	<b>Metrology 4: Thermometry</b> Lecture (9:15-9:45) Thermometry activities (9:45-10:45) Bring LabQuests, thermometer and conductivity probes  <b>Tour of Million Pound Force Machine</b> (11-11:45)	<b>Materials Sci 2/ Engineering: Walking Tour of WTC Structural Steel</b> (9-10)  <b>Experiment Design</b> (10:15-12N)	All SI participants, current and past, invited <b>Separations 4: Bioreactors</b> (9-10)  <b>Tour of Bioreactor Project</b> (10:15-11)  Westat Evaluation (11-11:45)
10-11										
11-12										
Lunch	Lunch	Lunch/Farmers Mkt	Lunch	Lunch with SURF students/West Wing	Lunch	Lunch with SURF students at NCNR	Lunch with NIST folks/West Wing	Lunch	Lunch	Group lunch out
1-2	<b>Metrology 1: Measurement Uncertainty How Big is Pi?</b> (1-2:30)  <b>Summer Institute Wiki, Twittering, Facebook</b> (3-4)	<b>Separations 1: Spectrometry</b> Lecture and Activity (1-3)  <b>Tour of NIST High Accuracy Spectrometer</b> (3:15-4)	<b>Sharing of labs tested in the morning</b> (1-2:45)  <b>Physics: Aerodynamics of Paper Airplanes</b> (3-4)	<b>Gel Electrophoresis/ Human ID Group Tour</b> (1:15-2:45 alternating) Implementation into curriculum (3-3:30) <b>SURF Seminar "Time, Einstein, and the Coldest Stuff in the Universe"</b> 3:30-4:30	<b>Scientist Visits</b> one-on-one (1-2) <b>Implementation into curriculum:</b> gel electrophoresis trials (2-3) <b>Separations 3: -Ink Identification with Thin Layer Chromatography (TLC)</b> (3-4)	<b>Diffraction Demos</b>  <b>Tour Part II</b> NCNR Staff  <b>Crystal Growing!</b>  <b>LabQuest Activities</b> (1-4)	<b>Metrology 3: Sampling Activity</b> (1-2)  <b>Technology in the Classroom</b> (2-4)	<b>Scientist Visits</b> one-on-one (1-2)  <b>The Earth 1: Solar system scale model activity</b> (2-3)  <b>Using NIST-based Activities in the Classroom</b> (3-4)	<b>SURF Student Panel Discussion</b> (1-2)  <b>Types of Magnetism</b> (2-3:15)  <b>SURF Seminar "Cancer Therapy with Magnetism"</b> (3:30-4:30)	All current and past SI participants invited <b>NIST Astronaut</b> 1:30-2:45  <b>Final Reception</b> Reception with all participating NIST staff invited (3-4)
2-3										
3-4										

Figure 1. NIST Summer Institute Schedule from 2009.



**Figure 2.** A middle school science teacher has her hands full with props she just built to teach about earthquakes and preservation of man-made structures in earthquake prone regions.

### 3<sup>rd</sup> NIST Summer Institute for Middle School Teachers *Week One*

Please rank these activities from 1-5 in terms of their usefulness to you, with 1 being the most useful and 5 being the least useful. Comments and suggestions are very welcome and will help us improve future Summer Institutes.

Date	Activity	Rank	Comments
Monday, July 6	NIST in Your Community Tour – Gail Porter	2	Very interesting Great speaker
Monday, July 6	Museum Tour – Keith Martin	4	Personal knowledge not sure if I can use it in class
Monday, July 6	How Big is Pi? – Dennis Leber and Hung-Kung Liu	1	Would be great for after-school program I'm doing
Monday, July 6	Wiki, Twittering, Facebook; Web 2.0 Allan Eustis	1	Want to try it!
Tuesday, July 7	Metrics Jeopardy – Elizabeth Gentry	1	Looking forward to reviewing measurement this year a first!
Tuesday, July 7	Weights and Measures – Georgia Harris, et al.	1	Very helpful! Great background info & activities
Tuesday, July 7	Spectrometry Lecture and Activity Steve Choquette	1	Great activity for physical science
Tuesday, July 7	Tour of HASI John Travis	4	Personal knowledge
Wednesday, July 8	LabQuest Trials	1	Couldn't use it without help!
Wednesday, July 8	Aerodynamics of Paper Airplanes Chandler Becker	2	Very fun engaging activity
Thursday, July 9	Solving Crimes with Science Lecture Janelle Newman	1	Great background info
Thursday, July 9	Forensics Science Experiments Janelle Newman and Jocelyn Prendergast	1	Fun & easy to do things that the kids will enjoy
Thursday, July 9	DNA Extraction Activity Mary Satterfield	1	Fun - perfect for life science!
Thursday, July 9	Lunch with NIST Scientists	3	Interesting - SURF students were especially friendly.
Thursday, July 9	Gel Electrophoresis Demo Margaret Kline	1	great background for me to use while teaching/doing
Thursday, July 9	Human ID Group Tour Amy Decker	3	Interesting to know what goes on.
Thursday, July 9	SURF Seminar – Time, Einstein, and the Coldest Stuff in the Universe	1	great talk!
Friday, July 10	pH of Water Ken Pratt	2	Helpful to know more about pH
Friday, July 10	Cement Activity Clarissa Ferraris	2	Fun - great inquiry activity - get to set own formula! - I do teach
Friday, June 20	Scientists Visits One-on-One	1	Student knows so much! Helpful to see how SURF works!
Friday, July 10	Gel Electrophoresis Trials	1	very helpful to try kit w/ other teachers!
Friday, July 10	Ink ID with TLC Bill MacCrehan	1	Something new for me - I really enjoyed it

Figure 3. Sample assessment from teacher-participant in NIST Summer Institute 2009.