AC 2011-1650: STEM PROFESSIONALS WITH CLASS

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STEM Professionals With Class

Project Introduction

By all accounts there is a great need to improve STEM (Science, Technology, Engineering, and Mathematics) education in the United States, and our city is not an exception. Many efforts on many fronts are being made nationally and locally to meet this challenge. However, one resource that is largely untapped is the vast pool of practicing STEM professionals. Although diverse efforts to facilitate collaboration between STEM and education communities have made positive impacts, only a small percentage of STEM professionals (hereafter STEMs), students and teachers have participated in these projects and few projects have enjoyed sustainability. Additionally, little research has substantiated the effects of the collaborations.

With funding from the National Defense Education Program via the Department of the Navy, this project implemented a testable model for effective collaboration between STEMs and middle school science teachers. The goals for the model are shown in Table 1. The table also shows the specific objectives for meeting each goal. Our research plan measured how effectively the project met the objectives.

Table 1. Goals and Objectives

Goal 1: Impact teachers' understandings of the work-lives of scientists and engineers, and via that impact teachers' abilities to connect classroom science instruction to real life science.

Goal 2: Impact students' understandings of the work-lives of scientists and engineers, and via that elevate student interest in pursuing science-related careers.

Below are the objectives for Goals 1 and 2. Teachers and students will:

- have a grasp of the nature of engineering and science, in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors. (This is also known as the nature of engineering and science processes.)
- know more about what a STEM does in the course of a day. For example, they talk to each other, do experiments, write explanations of their work for other people to read, look up information on the Internet, fix broken equipment, suggest ideas for work that need to be done, keep up with what other STEMs are doing, write computer programs, keep informed about new technology that might help their work, figure out how much it might cost to do a project, convince others that a project could yield useful outcomes, etc.
- know more about STEM careers, know that there is a place for people of all intellectual capabilities in STEM careers, have more interest in STEM careers. (Interest in STEM careers is only an objective for students.)
- see more relevance of STEM to everyday life.
- see scientists and engineers as 'normal' people.

Goal 3: Impact scientists' and engineers' ability to effectively communicate with teachers and students in order to improve teachers' and students' understanding of science and their knowledge about scientists' and engineers' work-lives.

The following objectives will be examined to determine whether Project Goal 3 is met. STEMs will:

- provide a taste of a day in the life of a scientist or engineer for the students.
- elevate student interest in STEM, and in STEM-related careers in science.
- help students see more relevance of STEM to everyday life.
- help students see scientists and engineers as ‘normal’ people.
- help students have a grasp of the nature of science and engineering, in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors.

In our project teachers were immersed in three different R&D efforts on the campus of the Space and Naval Warfare Systems Center Pacific (SSC Pacific) a major Naval laboratory in San Diego. Teachers spent one day with each group. A STEM from each group reciprocally visited and shared expertise in the teachers' classrooms. Although this approach is not novel, the details and support for these interactions separate this project from other STEM/teacher collaborations. This model was designed with the key elements listed below and subsequently elaborated.

I. Identify Science Teachers
II. Identify STEM Professionals
III. Project Kick-off, Orientation for all partners
IV. R&D immersion in industry settings
V. Classroom Collaboration
VI. Research on Program Effectiveness

I. Identify Science Teachers. For the sake of this research effort exemplary teachers were recruited from the Middle School Science Education Leadership Initiative (MSSELI) program. The goal of MSSELI is to identify lead science teachers from San Diego City and County middle schools. Once identified, these teachers participate in an intensive summer and academic year professional development program focused on science content, leadership strategies, and collaboration with scientific institutions. During August 2009 grade eight science teachers were recruited. Nine eighth grade teachers participated in the treatment and four teachers acted as controls. Grade eight was selected as the target audience because of the alignment of physical science content expectations for students and SSC Pacific activities. The participating teachers represented seven school sites and six unique school districts. The project paid for substitute teachers for the days that participating teachers were at SSC Pacific. Teachers did not receive stipends for participating in the project with the rationale that they were benefitting from their participation. Control teachers were offered $250 for the extra work of administering pre and posttests.

II. Identify STEM Professionals: Six STEM professionals were recruited from SSC Pacific by their outreach office. STEMs were identified based upon their prior experience with K-12 education outreach and/or interest in hosting teachers and in visiting classrooms. STEM recruitment occurred in August & September 2009. The cost of the STEMs' time was borne by SSC Pacific.

III. Project Kick-off and Orientation: The project began with a full-day kick-off meeting at the SSC Pacific facilities in September 2009. In the morning teachers and project staff toured the facilities and met many of the participating STEMs. Several STEMs from their New Professional Program joined teachers for the tour and lunch, describing their educational journeys and entry into STEM professions. In the afternoon STEMs made brief presentations about their work and described what teachers would do should teachers have an immersion with his/her group. The kick-off accomplished acquainting teachers with the R&D facility and staff, initiating relationships between teachers and STEMs, and introducing the project goals and objectives.

IV. R&D Immersion: Each STEM hosted a group of three science teachers for a full-day immersion on at least one occasion. During these immersions teachers were engaged in engineering and science experiences, team meetings and other authentic experiences to approximate the typical work of the STEM. Choosing a ratio of one STEM to three teachers was intentional. STEMs are familiar with hosting visitors and presenting their work but teachers rarely interact professionally with others outside of their profession. The 1:3 ratio was chosen to insure that teachers were comfortable and had the opportunity to process the events of the R&D immersions with other teaching professionals. The goal of the immersions was to give teachers a context for real-world engineering and science practices that may relate to and extend core school instruction (Project Goal 1). Objectives and guidance for the R&D immersion were distributed to STEMs and teachers, and are appended to this paper. Our project manager was responsible for scheduling immersions to occur between October 2009 and January 2010. Internet communication minimized the amount of time required to organize visits. Three teachers and one project staff member visited each lab. Two STEMs hosted multiple immersions. Table 2 provides a brief overview of the activities in each immersion.

Table 2. Overview of R&D immersion activities

Lab Focus	**Visit Summary**
Robotics	Teachers were assigned to find the maximum communication range for an actual field robot. Teachers needed to determine a method for doing this, then took the robot to a test site that approximated terrain in the Middle East. After collecting field data, teachers returned to the lab to analyze and write up their findings. Some of the teachers' questions prompted their host to bring in a communications expert in to help understand the findings.
Speech Technology	A presentation introduced teachers to some roles of speech technology in society, and then teachers experimented with two types of speech recognition programs.
Laser Vibrometry	Teachers received training in the use of lasers, and were given background on vibrometry. Teachers then used that knowledge to assemble a device that could detect an object in the distance such as a figure or machine assembly.
Bioluminescence	Teachers performed an experiment to measure the bioluminescence of different samples of populations at different water flow speeds.
Antenna Range	Teachers studied patterns of interference on scale models of ships.

Nanotechnology	Teachers engaged in a problem solving exercise to determine a strategy to cut delicate solar panels. They utilized an excimer laser to make the cut, and then studied the cut edge under an electron microscope.

V. Classroom Collaboration: In pursuit of Project Goal 2, STEMs visited the eighth grade classrooms of the teachers who were immersed in his or her lab. Classroom visits consisted of a brief presentation by the STEM regarding his/her professional life and field of work, followed by a hands-on activity devised by the STEM. Prior to the visits guidelines for the classroom collaboration were distributed to STEMs and teachers and are appended to this paper. Teachers and STEMs were encouraged to touch base with each other before the STEM's classroom visits. Pursuant to Project Goal 3, a project staff member contacted each STEM prior to the classroom collaboration to answer questions and offer help in preparing for the visit to the STEM's first school. A staff member observed the STEMs' first visits to offer constructive feedback and insure that the collaboration met the project's objectives. An observation protocol is appended. Teachers also offered feedback to STEMs. Whenever possible, STEMs visited all class periods of a teacher's science classes.

Our project manager was responsible for scheduling collaborations. Collaborations occurred between January and May 2010. It was difficult to schedule visits so that the STEMs' presentations topically coincided with the eighth grade curriculum but teachers made connections to past or future topics. STEM classroom activities included:

- One STEM from a communications group brought small transmitter and receiver sets for students to explore. The sets demonstrated how facilitated sound information travels along a light path. Students connected an MP3 player to the transmitter and heard the signal via an ear bud connected to the receiver.

- A visit from a robotics specialist consisted of an overview of the STEM's school and career path as well as outside interests, followed by a chance for students to control a robot.

- One STEM from the laser group brought laser pointers, mirrors, protractors and string for the students to create a path so that the laser light would be directed toward a target.

Research on Program Effectiveness

Research was conducted to test this model. The research compared an experimental group of nine eighth grade teachers and their students with a control group of four eighth grade teachers and their students. Both quantitative and qualitative research methods were utilized and are described below.

Student Research Questions and Methods

These research questions were crafted to measure project impact with regard to Project Goals 1 and 2. The research questions are directly linked to their objectives. As a result of the teachers' experiences and STEM classroom visits, do students:

- have a grasp of the nature of science and engineering, in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors?
- know more about what a STEM does in the course of a day? For example, do they talk to each other, do experiments, write explanations of their work for other people to read, look up information on the Internet, fix broken equipment, suggest ideas for experiments that need to be done, talk about the importance of different experiments, keep up with what other STEMs are doing, try to come up with reasons that an experiment turned out the way it did, write computer programs, keep informed about new technology that might help their work, figure out how much it might cost to do a research project, convince others that a research program could yield useful results, etc?
- know more about STEM careers? Do students know that there is a place for people of all intellectual capabilities in STEM careers? Are students more interested in pursuing a STEM career? What has changed in how they view STEM careers?
- see more relevance of STEM to everyday life?
- see engineers and scientists as 'normal' people?

Students' completed a 26 item online questionnaire in January prior to STEM visits to the classrooms, and in June after STEM visits were over. The questions on the questionnaire are appended. We adopted or modified published assessment items [1, 2, 3] and we developed new ones. Several staff and teachers checked the questionnaire clarity and language level.

Each item on the questionnaire was crafted to address one of the objectives above. Nine hundred students answered the pretest, and 612 students answered the posttest. The data analysis addresses only students who completed both pre- and post- questionnaires: 189 students from six treatment teachers, and 149 students from four control teachers. Reasons for the difference in total vs. paired respondents include the fact that some control teachers had different classes for the pre- and post- surveys, student transfers and absences, and the very busy nature of the end of the school year.

A two-way paired student's t-test was used to compare pre- and post- responses for each of 26 items for both the treatment and control groups. We also performed a two-way unpaired student's t-test analysis comparing the change in the treatment group (with change defined as post-score minus pre-score) to the change in the control group.

Students also completed free response reflections at the conclusion of each STEM classroom visit.

Student Research Findings

The analysis of the surveys shows no significant ($p<0.05$) differences between students' pre vs. post responses, or between the treatment and control groups, in these four areas:

- their understanding of the nature of engineering and science
- their knowledge about STEMs' work
- their perception of STEMs
- their understanding of the relevance of STEM to everyday life

A single item within the area "becoming a STEM in the future" shows a significant difference. For the item, “I will not be a scientist or engineer when I grow up,” students’ answers were assigned a score of 1 to 5, with 5 corresponding to the most desired answer (strongly disagree) and 1 to the less desired (strongly agree). The results are summarized below:

> The average for the students in the treatment group was 2.67 for the pre and 3.06 for the post. The difference, 0.39, is statistically significant with $p<0.0001$.
>
> The average for the control group was 2.97 on the pre and 3.07 on the post. The difference, 0.10, is not a significant difference with $p=0.36$.
>
> When comparing the change in the intervention group with the change in the control group, that is 0.39 vs. 0.1, it is statistically significant with $p=0.029$.

The table below presents data for the statement “I will not be a scientist or engineer when I grow up.” Looking at the standard deviation for the mean of Intervention and Control groups, the difference of 3.06-2.67 for their pre is small compared to the standard deviation, suggesting that the groups were correctly matched.

	Intervention pre	**Intervention post**	**Control pre**	**Control post**	**Intervention change**	**Control change**
Mean	2.67	3.06	2.97	3.07	0.40	0.10
Standard Deviation	1.21	1.11	1.13	1.04	1.22	1.26
Number	187		146			
Percent	less than 0.0001		0.3598		0.0290	

According to the student questionnaire results it seems that the project had a positive influence on students’ desires to go into STEM professions.

Students in the intervention group were very enthusiastic about STEMs’ visits to classrooms; This is reflected in students’ writings on what they learned from STEM visits. In general, it can be seen from their write-ups that students enjoyed the experience. Below is a sample of representative answers, categorized by theme. Student comments are verbatim and occasionally contain grammatical errors, etc.

Content statements

- *I learned that laser colors are that because of the number of nanometers that the laser has*
- *On a mirror a laser reflects opposite direction on an angle*

- *Vocal cords don't vibrate when you say "s"*

Careers

- *Now I know the difference between a scientist and an engineer.*
- *I learned that to get into speech technology you just have to have a bachelor's degree*
- *They are looking for engineers*

Relevance

- *Many people on the military use lasers*
- *Lasers are used in many ways, like for the eye surgery and blue rays.*
- *I bet that's what the police use to identify people trough phones*
- *I learned you could identify who is talking by their voice. You can also tell gender, mood, vocal pitch and accent.*

Interest

- *Lasers can be fun to play with*
- *I am thinking about downloading those applications ("Audacity" & "Natural Reader") because they seem like a lot of fun. I did not know science could be so fun*
- *I like having scientists coming to Ms W. classroom and teaching us about different kinds of science*
- *I really like speech technology. It is very interesting*
- *I think speech technology is cool and fun and I probably want to do this in life, so fun or good use.*
- *You must love your job and I think you have a fun time doing your job*

Teacher Research Questions and Methods

As a result of R&D immersion experiences and STEM classroom visits, do teachers:

- know more about what a STEM does in the course of a day? (See student section above for an elaboration.)
- know more about the nature of science, in particular, the practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors?
- know more about different careers in STEM and the characteristics of people in them?
- see more relevance of STEM to everyday life?

Teachers completed a pre-survey and post-immersion were interviewed by telephone.

Teacher Research Findings

When asked about the R&D immersion days:

- Six teachers mentioned learning about the scientific process. In particular, they expressed that they learned about problem solving skills of STEMs, that scientific equipment is not perfect and that STEM work is a trial and error process in which you learn also from the wrong answers.

- Five of them also referred to the fact that science is a collaborative enterprise, in which STEMs work together.
- Other influences mentioned were: revived passion for science, increased content knowledge, introduction to new equipment and current science, realization of the demographic diversity of STEMs (gained via visits to the labs), a better understanding of how STEMs spend their day, new knowledge about scientific career paths, and a new appreciation for the importance of math.

Regarding how R&D immersions connected to their classroom teaching:

- It was common for teachers to spontaneously connect STEM practices to classroom practices. In particular, four teachers said that STEMs' collaboration is like what their students do in class and that this experience reinforced that it is important to let students figure things out.
- Three teachers expressed that they shared with their students what they did in the labs and the students were excited.
- Other teachers mentioned that they tried to apply what they learned about the scientific process to their classrooms to make the labs less cookbook and more open ended; to not tell students the answers; to foster thinking out of the box; to focus less on content and more on process; to help students understand that you can also learn from wrong answers, to bring up awareness that everyone can be in science (diversity); and to bring up things learned in robotics when learning about force and motion.

When asked about what they learned regarding the work life of STEMs:

- Eight teachers said that as a result of the R&D immersion days and classroom visits, they knew more about what a STEM does in the course of a day. Specifically they mentioned that they learned about the type of problems STEMS solved; that experiments can take a long time; that communication is a key issue for STEMs; that STEMS had a lot of paperwork, read books, interact with people at other institutions, use notebooks and have funding issues.

When asked about their perceptions of engineers and scientists:

- Teachers mentioned that they now have more respect of the writing/publishing activity of STEMs, that they knew more about the variety of venues engineers can pursue in their profession, that they were impressed about the amount of collaboration, and that the experience enlighten them about the fact that STEMs focus on process over content.

When asked about the nature of science, and application of science and engineering to everyday life:

- Three teachers answered that they are now more aware of how to apply what they learned to teaching.
- Four teachers said that not much changed, but the experience reinforced what they knew (i.e., the importance of writing or communicating).
- Seven teachers said they knew more now about how science/engineering is relevant to everyday life, as they saw specific examples, like speech technology or lasers.

When asked whether they thought that STEM classroom visits impacted their students.

- All nine thought that the experience was powerful for their students. As evidence they mentioned that students kept talking about robots and lasers and wanted to do more activities, and that during the STEMs' visits students were engaged and asked questions.
- They said that as a consequence of their interaction with the STEMs and the equipment they brought, students were stimulated to learn more science and work in a STEM profession.

When asked whether the experience was worth their time and if they would recommend it to a colleague, all nine teachers were very enthusiastic.

STEM Research Questions and Methods

As a result of R&D immersion experiences and classroom visits, did STEMs think their classroom visits accomplished any of the following objectives?

- provide a taste of a day in the life of a scientist or engineer for the students?
- elevate student interest in STEM, and in STEM-related careers in science?
- help students see more relevance of STEM to everyday life?
- help students see engineers and scientists as 'normal' people?
- help students have a grasp of the nature of science and engineering, in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors.

STEMs were interviewed by phone by the project evaluator. Although the following is not included in the objectives for the participating STEMs, the project evaluator included these questions in the interview protocol. Did STEMs:

- Change their thoughts about what happens in a middle school science class?
- Change their classroom presentations based upon student/teacher feedback?

STEM Research Findings

When asked whether their thoughts about middle school science classes changed:

- Two of the STEMs said that their initial thoughts about what happens in a middle school science class didn't change as a result of participating in this project, because they already have experience in classrooms or with their own kids.

- From other STEMs
  - They were surprised about that students don't do labs, and even if they do experiments, they are focused in finding the right answer and don't really get the idea of scientific process.
  - It was the first time they thought about how to approach students from a teaching perspective.
  - Were surprised for the good quality of the teachers and for the interest of the students, especially when the students were involved.

When asked whether they made changes to classroom presentations:

- All the STEMs mentioned making changes to their classroom presentations based upon student/teacher feedback.

- They tried to bring to class materials that students relate to, tried to adapt to special needs of the students, broke their talk down to focus on main targets, and decided to introduce more interaction with students from the beginning, rather than giving a talk and only later start students' participation.

- One of them changed the subject of his talk based on a teacher's suggestion.

When asked what they think the teachers got from the day in their lab:

- One STEM mentioned that teachers were surprised by how much math was used, by how old the equipment was, and by the fact that the professionals used books. The level of frustration also surprised teachers when things didn't go as expected, and by the need to think of modifications on the fly.

- Another STEM said that the teachers had lot of career questions. This experience helped them ground their teaching into something more real.

- Another STEM said that teachers learned about the inquisitive nature required to be in a lab (thinking of an experiment, carrying it out and figuring out the results). They were also surprised that research doesn't always require high cost materials.

- Finally, another STEM expressed that teachers learned about new technologies and how to solve practical issues.

When asked about which of the objectives established for the classroom visits they think were accomplished,

- Two STEMs thought they achieved the goal of helping students acquire a grasp of the nature of science (in particular, the practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors).

- Two of them thought they achieved the goal of helping students find out about the kind of activities engineers and scientists do in the course of a day.

- Three of them thought students were able to learn about STEM careers.

- Three of them thought they achieved the goal of helping students see the relevance of STEM to everyday life, and two thought they improved students' view of STEMs as 'normal' people with families, hobbies, etc.

When asked about whether the project was worth their time and whether they will do it again and/or recommend it to someone else

- All of the STEMS said that they thought the project was worth their time, and that teachers and students benefited a lot from it.

- However two expressed concerns about the amount of time required for the project.

- One mentioned that she thinks the next step should be for teachers and STEMS to develop together material to make the talks fit into the class flow (for preparation before the visit and as a follow up). The need to have other people that can give the talks, besides the involved STEMs was also mentioned.

Project Summary, Observations, and Recommendations

Although quantitative data was difficult to acquire, STEM Professionals with Class seems a success as evidenced by feedback from all involved groups-- students, teachers and STEMs. As with all programs, there are areas where the project could be modified or improved in future iterations.

Ensuring that all participants fully understood the project goals and objectives, and used them to design project activities presented a challenge. Project staff spent significant time developing R&D immersion and classroom collaboration support materials that detailed the project goals and objectives. The R&D immersion guidelines were faithfully used, perhaps because the lab liaison emphasized them to the STEMs. However, even though the project director made personal phone calls to each STEM to discuss their classroom collaborations, no STEM remembered any of the classroom collaboration objectives during their exit interview with the evaluator. We recommend that future projects utilize time during the kick-off meeting to discuss the objectives for both areas.

Getting students to complete both the pre- and post- online survey was a challenge, as evidenced by the relatively low number of paired respondents (under 400) compared to total respondents (over 900). Treatment teachers did not receive compensation based on student survey completion, so future projects may wish to consider adding a small stipend to ensure completion. However, control teachers did receive a small stipend for student survey completion, and even this did not result in 100% response. One factor may have been that the post- survey was administered too close to the end of the school year, and future projects should more carefully time evaluation efforts.

Providing more structure for collaboration between teachers and STEMs would help to ensure that STEMs classroom collaboration visits are timed to fit in with what students are learning, that classroom activities are at an appropriate difficulty level, or to provide more scaffolding for complex activities, and offer an opportunity for teachers to prepare their students with pre- visit activities or use the visit as a springboard for subsequent activities.

We are curious as to why the online questionnaire only captured a difference between the control and experimental groups on one question since we received such positive feedback from teachers and students, and we observed such enthusiasm from all parties involved. One possibility is that our questions need to be refined.

Other minor suggestions are to include a small classroom materials supply budget for STEMs since classrooms likely do not have the necessary supplies, scheduling R&D immersions earlier in the year, and keeping the level of math a bit lower.

To celebrate the success of the project, a poster was created to highlight the program and its participants. The poster was presented at a celebratory reception for teachers, STEMs, and project staff. This event offered a chance for everyone involved in the project to share his or her successes, reflections, and ideas for working together in the future.

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(Appendices start on next page.)

Appendix A

STEM PROFESSIONALS WITH CLASS
The Engineering and Science Immersion Experience

Introduction. This document describes engineering and science immersion experiences intended for teachers participating in the *STEM Professionals with Class project*. The purpose of the immersions is for teachers to experience the processes that happen in genuine engineering and science settings; in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors. Unfortunately educators typically do not have the opportunity to experience this. This lack of authentic, applied, or ”real world” experience has frequently led educators to view engineering and science as encyclopedias of information and to teach it accordingly. The STEM immersions provide an opportunity for teachers to participate in genuine engineering and science endeavors and to ultimately bring this experience to bear on their classroom instruction.

What kind of experiences should teachers have in STEM settings? As stated above, giving teachers the opportunity to genuinely engage in logical, evidence-based reasoning, inquiry and communication is a priority in this project. The following are some suggestions on how teachers could experience this. Some labs may be able to offer some of the opportunities described below, other labs may be able to offer different opportunities to achieve this same goal. Regardless, *immersions should offer opportunities such that the focus is on the teachers' active participation in the engineering or scientific process*. Teachers could:

- Discuss the questions that an experiment is helping to address. This should include the experiment question and how this experiment fits into a broader research agenda. Teachers should be encouraged to ask their own questions about the research agenda and/or experiment.
- Offer a prediction or hypothesis and discuss the reasoning for it. The hypothesis could be about an experiment being conducted in the lab, or about some other issue related to the research agenda. The critical experience for the teacher is discussing his or her reasoning. The correctness of the hypotheses is not important. It also does not matter whether teachers' hypotheses are based on accepted canon or everyday experiences like riding a bicycle. The important aspect is that teachers make predictions/hypotheses based on evidence and logical reasoning. The discussion should approximate the kinds of discussions that occur among scientists or engineers. Lab staff should ask teachers questions to really try to understand what teachers are thinking – just as you would when discussing your work with a STEM colleague. (In a group of teachers, every teacher does not need to offer a unique hypothesis, but each teacher should participate in a discussion of the reasoning.)
- Collect data by making observations. Observations could include descriptions of behavior or making measurements. Teachers should evaluate and interpret the data. This process should include discussion of the strengths and limitations of the data in drawing conclusions.
- Be exposed to a range of data analysis from simple pattern recognition to advanced computer analysis. Teachers should evaluate and interpret the analysis. This process should include judging the merits and faults of the analysis.

Does learning canon play a role in the immersion? Teachers may learn scientific or engineering canon, but it is not the purpose of the immersions.

What is the role of the STEM staff? STEM staff should help teachers experience the processes that happen in genuine STEM settings. Lab staff should not view themselves as teachers, but rather as scientists giving another group of professionals a real taste of what it is like to engage in a scientific or engineering endeavor. Encourage discussion and be open to teachers' questions. Avoid giving lengthy impromptu science lectures. Teachers might be nervous about sharing their ideas. Lab staff should be respectful and encouraging, nurturing teachers' active participation in the immersion. Teachers are in this project to genuinely engage in STEM processes.

What is the role of the teacher? Teachers should actively engage, think, ask questions and contribute to discussions. Make the most of this opportunity to participate in a genuine STEM laboratory. Don't be timid! Also be aware that the lab staff is graciously making you a part of their work, and be understanding if they cannot grant a request. Special requests should be made through appropriate channels.

Appendix B

STEM PROFESSIONALS WITH CLASS
The Classroom Collaboration

In the Classroom Collaboration, STEM professionals have the opportunity to excite and influence middle school students. Thoughtful planning for the Classroom Collaboration can maximize the impact for all participants. The following sections have important information to consider while planning for the Classroom Collaboration.

Goals for Students for the Classroom Collaboration

STEMs and teachers should plan the Classroom Collaboration so that it addresses as many of these goals as possible. To maximize student impact, teachers should continue to weave these goals into their science classes as is possible.

- Students will acquire a grasp of the nature of engineering and science, in particular the rich practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors.
- Students will find out about the kinds of activities that engineers and scientists do in the course of a day. For example, they talk to each other, do experiments, write explanations of their work for other people to read, look up information on the Internet, fix broken equipment, suggest ideas for experiments that need to be done, talk about the importance of different experiments, keep up with what other scientists are doing, try to come up with reasons that an experiment turned out the way it did, write computer programs, keep informed about new technology that might help their work, keep up with current events that could influence their work, figure out how much it might cost to do some research, convince others that a research program could yield useful results, make presentations, etc.
- Students will learn about STEM careers. Students will learn that there is a place for people of all types in STEM careers, i.e. some people are good in math, some people are good at fixing things, some people are good at applying scientific theories, etc.
- Students will see more relevance of STEM to everyday life.
- Students will view engineers and scientists as 'normal' people with families, hobbies, etc.

Guidelines for the Classroom Collaboration

- Teachers and STEM Professionals should communicate logistical information about dates, times, class periods and student preparation prior to the Classroom Collaboration. Specific information about classroom technology, safety, demonstration areas and student involvement should be exchanged.
- Teachers and STEMs should work together to plan the visit. Remember, the teacher is the education expert and the STEM is the STEM expert! Planning together is essential for maximum success. A typical Classroom Collaboration might consist of a 10 - 12 minute presentation by the STEM and the remainder of the class period devoted to students engaging with a demonstration or activity. Student engagement is essential.
- STEMs, be lively, friendly and informal with the students! Show excitement about the fields of engineering and science, and about your work in particular. Ask students what they already know about your topic. Ask how they think a engineer or scientist works to find out about the topic being presented. Engage with the students as much as possible. Have fun! The more students can relate to you, the greater the impact that you will have.
- STEMs, in your talk, describe "a day in my life as a engineer/scientist." Invite questions about being an engineer or scientist. Be prepared for some common questions such as what is your salary or a typical starting salary, how long did you go to school, do you need to get all A's to be a scientist or engineer, etc.
- Teachers, at the beginning of the class let students know that they will be asked to do a quick-write exit slip on Three Things I Discovered Today, or a similar prompt. Collect their papers to get feedback on the session.

- Teachers, remain involved throughout the visit of the STEM Professional. Interject questions, pause the class to clarify vocabulary, data or instructions as needed. Make suggestions between classes to make the experience even better for the students.
- Project observers may attend some Classroom Collaborations. Project observers may share observations and make suggestions between classes, but will not participate during the class session. Information on all aspects of the Classroom Collaboration will be made available to participating teachers, STEM Professionals, school and project administrators.

Effective Instructional Strategies

- Begin with the end in mind. State 3-4 objectives for student learning. Use the strategy of telling the student what they are going to learn, engaging them in the learning, and ending by giving them an opportunity to express ideas about what they have learned.
- Limit upfront talking to no more than 7-minute chunks, giving students time to interact and use the information being presented.
- Use accessible language when describing STEM work, and be especially aware of language used to identify tools, visualizations, graphic data, etc. Help students un-pack what important terms mean. For example, ask students what they think "Speech Technology" means before telling them it is using technology tools to study speech.
- Throughout the Classroom Collaboration students should be given the opportunity to revisit how information and data contribute to the next steps in thinking about, designing or using information presented.

Appendix C

STEM PROFESSIONALS WITH CLASS
Student Survey with Questions Categorized

Sudents choose a score of 1 to 5, with 5 corresponding to the most desired answer (strongly disagree) and 1 to the less desired (strongly agree).

Interest in STEM

- I like doing things with nature such as collecting rocks, looking at stars, looking for seashells, and so on.
- Science is one of my favorite subjects in school.
- I like reading about nature topics like ocean animals, dinosaurs, volcanoes, swine flu, and so on.
- I like finding out how things work, such as computers, the Internet, cell phones, and so on.
- I like finding out things about nature, such as why the sun is hot, what causes thunder and lightning, and so on.
- I do **not** like watching TV programs such as Discovery Channel, Mythbusters, Animal Planet, National Geographic, and so on.
- Science is boring.
- I do not like reading about topics such as computers, space flights, robots and so on.

Relevance of science and engineering to everyday life

- Knowing about science and technology can help decide whether to recycle paper and glass.
- Knowing science helps figure out how things work, like refrigerators, bicycles, birthday candles and so on.

- Scientists and engineers work on everyday problems like how to make the best soap for washing clothes, or how to provide electricity to people who are far away from power factories, and so on.
- Science and technology have nothing to do with my life.
- Knowing about science and technology will not help doctors decide how to treat a sick person.

Self-perception relative to science

- Someday I might look for a job in science or engineering such as making new medicines, creating new cell phones, or so on.
- I am confident that I can learn science.
- I will not be a scientist or engineer when I grow up.
- Only the smartest students can learn science.

Perception of scientists and engineers

- Scientists and engineers are normal people who love to figure out how things work.
- Most scientists and engineers are nerds.
- It is very hard for scientists and engineers to talk to normal people.
- Scientists and engineers investigate weird things that only they understand.

Nature of science

- Scientists and engineers ask lots of questions in their work.
- Scientists and engineers discuss their questions and ideas with others.
- When a scientist or engineer works in a specific field (such as cancer research), he has to know all the answers in that field.
- Scientists and engineers work all alone.
- Scientists and engineers need to know all science knowledge before they start working.

Appendix D

STEM PROFESSIONALS WITH CLASS PROTOCOL FOR FORMATIVE FEEDBACK

School: Date:

Teacher: STEM: Observer:

Write as much information as you can

- Students had the opportunity to acquire a grasp of the nature of science and engineering, including the practice of logical, evidence-based reasoning, inquiry, and communication that characterizes these endeavors.

- Students found out about the kinds of activities that scientists and engineers do in the course of a day. (See Student Research Questions for examples.)

- Students had the opportunity to learn about STEM careers, and that there is a place for people of all intellectual capabilities in STEM careers?

- Students had the opportunity to see relevance of STEM to everyday life.
- Students had the opportunity to view scientists and engineers as 'normal' people with families, hobbies, etc.
- Teacher and STEM worked together to plan the visit.
- STEM was lively, friendly and informal with the students. STEM showed excitement about the fields of engineering and science.
- STEM described "a day in my life as a scientist/engineer."
- STEM invited questions about being an engineer or scientist. What were some of the questions?
- The presentation and visit was well organized and at an appropriate pace for student learning.
- The STEM used accessible language and when necessary helped students un-pack what important terms mean.
- The talk had visual support/demos that made it more concrete and appealing.
- What percentage of students looked engaged? How many students asked questions? What were some of the questions students asked?
- Teachers assigned and collected a quick-write from the students.
- Teachers remained involved throughout the visit of the STEM.

Overview of visit: