AC 2011-1577: POSTER-BREATHING LIFE INTO THE SCIENCE FAIR PROCESS

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Kellie Marcarelli is a middle school science teacher and department chair at Pershing Middle School in the San Diego Unified School District, where she teaches eighth grade physics and chem- istry. Beyond the classroom, Kellie serves as a trainer, teacher-leader, curriculum evaluator and assists in the screening process for the Greater San Diego Science and Engineering Fair. Her professional experience includes working as a staff developer for the Middle School Science Education Leadership Initiative (MSSELI), the California Math and Science Partnership program, and the San Diego Unified School District; presenting regularly at NSTA's national conference as well as state and regional science education conferences, and working with WestEd's K12 Alliance. She is also actively involved in STEM outreach with local professionals in the science community. She is the recipient of the California State Science Fair Teacher of the Year, the San Diego Science Alliance Partnership Teacher of the Year, and the Greater San Diego Science and Engineering Fair Teacher of the Year awards. Kellie's passion for using interactive notebooks in the science classroom grew out of her desire to improve student learning and to provide students with a method for organizing their metacognitive thoughts. She believes that the students are scientists, therefore they should act like scientists and document their findings and ideas.

Susan Benson, Pershing Middle School

Susan is an eighth grade science teacher. For seven years she has guided students through their mandatory school science fair, into the county science fair and even to the state science fair. She has collaborated with science professionals for 2 years during science fair and has enjoyed seeing her students improved investigation and experimental skills.

Heather Marie McCormick, Pershing Middle School

This is Heather's second year with the science fair program at Pershing Middle School. As a new teacher, the professionals and scientists have been very helpful. She enjoys guiding the students through the scientific method and has seen many successes in the school and county science fair.

Breathing Life into the Science Fair Process

Abstract

Science, Technology, Engineering, and Mathematics (STEM) are at the forefront of our nation's agenda. Both national and global advancement and sustainability are contingent upon fostering discovery and development in the STEM disciplines. Many middle and high schools require students to complete science fair projects in an attempt to raise the level of students' awareness of science and to provide the student with scientific and inquiry skills. While many students may look to their family or friends for support, without know anyone with a sufficient background in any of the STEM fields, most students in urban schools rely heavily on their teacher as the primary source of scientific guidance. This can mean hundreds of students being guided by a single teacher, limiting the effectiveness of and enhancement to the science fair process. This paper defines a successful model which invites scientists and engineers from local research labs into the classroom to assist teachers and students by bringing relevance and knowledge to the science fair process. The three main objectives of the project were for the scientists and engineers to 1) provide relevance to learning science and performing a science fair project; 2) provide scientific mentors to work with a limited number of students to enhance the student's learning and capability; and 3) provide the science inspiration for lower performing students to produce a successful science fair project.

Introduction

The first science fair west of the Mississippi River was held in Los Angeles in April 1952. Since that time, science fairs have continued to grow and attract higher level projects as well as scholarship opportunities and recognition for students and mentors. On November 23, 2009 President Obama launched the "Educate to Innovate" campaign to increase participation and performance of America's students in STEM. As part of the campaign, President Obama held the first White House Science Fair, where middle school and high school students from across the country displayed their award winning projects for the President to review. Inquiry-based learning is recognized in the national science standards such that, "learning science is something students do, not something that is done to them." [1] Science fairs are recognized as a way for students to make new discoveries through inquiry and design as well as develop mathematical, writing, and presentation skills.

While the benefits of science fair can be great, in large city urban schools, many science teachers bear the burden of providing the only assistance for students conducting science fair projects. While many schools value the science fair process, some teachers and schools determine that the effort is too difficult and do not require participation in the science fair as part of the curriculum. Pershing Middle School is located in San Diego, California and is the setting for the pilot project described in this paper. The school is an advocate of developing strong science students and has required eighth grade students to complete science fair projects as part of the science curriculum for eight years. Over those years, as a result of frustration, apathy, social issues, and lack of individual guidance from the teachers, many students wither did not complete a science fair project of completed a project that barely met the minimum standards. The school administration

and teachers recruited some parents as well as English and math teachers to assist in the process, but still felt that a great depth of expertise in the STEM fields was needed to take the students through the process to a higher level of science understanding.

The benefit of having scientists and engineers in the classroom is not a new discovery. This is a model that seeks to provide content expertise and enthusiasm from practicing professional to the classroom.[2] Short duration interventions are primarily based on changing attitudes toward science and developing interest and enthusiasm.[3] Space and Naval Warfare Systems Center Pacific (SSC-Pacific), under the direction of the National Defense Education Program, decided to send scientists and engineers into classrooms under the Bybee/Morrow roles of resource and partner.[4] SSC-Pacific established a partnership with Pershing Middle School. Scientists and engineers from the research lab have been supporting the classrooms with speakers, demonstrations, and science fair judges since 2007. During this time, the teachers began to see the value added by having a professional scientist or engineer working with middle school students. Three main advantages seem to emerge:

- Providing relevance to real world problems and technologies could be presented by scientists and engineers working in the field; thereby making the science come to life for the students
- Presenting experiments with "cool" equipment that is readily available to the research lab can enhance the classroom experience for the students
- Validating the curriculum, textbook, and teacher presentations

Over time the scientists, engineers and teachers developed a relationship of trust and respect with each other. The teachers solicited help from the professional scientists and engineers with the science fair process. A team made up of three eighth grade science teachers, the school principal, and two scientists from the research laboratory met numerous times at the beginning of the school year in 2009 to develop a model to execute during the 2009-2010 school year.

Science Fair Process Model

For Pershing Middle School, the science fair process takes place from the middle of October through the end of January. The primary mission of the teachers during this time is to assist over 300 eighth-grade students in completing a science fair project. The team of science teachers, principal, and scientists determined that the goals of the model to bring the scientists and engineers into the science fair process would be to:

- Provide relevance to learning science and performing a science fair project
- Provide scientific mentors to work with a limited number of students to enhance the student's learning and scientific skill sets
- Provide the science inspiration for lower performing students to produce a successful science fair project

Some challenges to overcome:

- Time and Cost required to send scientists and engineers into the classroom during working hours
- Ensuring the scientists and engineers would work well with middle school students
- Determining the most appropriate times within the science fair process that the scientists and engineers would be most effective

After much discussion, it was determined that the research lab,SSC-Pacific, would provide at least one scientist and engineer in each of the three eighth grade science classrooms four times during the science fair process. The teachers determined that the most useful times for the scientists and engineers to actively participate in the classroom would be:

- At the beginning of science fair process (mid-October)
- During the testing process (Mid-December)
- During graphing, interpretation and presentation process (Mid-January)
- During the student oral exhibition judging (Late-January)

To ensure the scientists and engineers were prepared to work with middle school students, the research lab held training sessions for them to go over responsibilities and goals of the project. For the four visits, the scientists and engineers visiting would attempt to remain the same for consistency throughout the process.

Results of Model

Visit 1 - Beginning the science fair process:

Two scientists and one engineer spent the entire school day in the three eighth grade classrooms. In October 2009, the scientists and engineer visiting the classrooms prepared a short presentation on how they use the scientific process in their work and then worked one-on-one with students to assist in the development of an idea and hypothesis for a science fair project. The scientists and engineer provided inspiration by questioning students about their interests, topics and ideas. Many ideas, that the teachers had not thought possible, were able to be realized as the scientists and engineer determined appropriate procedures as well as offered to loan equipment necessary to perform the experiments. In seeing that there was an outside individual who cared about their success, this process of the model was especially important to the lower performing students as they were led through the process of finding a project that was of interest to them.

Because the teachers had a preparation period in between the first and third period classes, the teachers, scientists and engineer had time to reflect on the first class, discuss other ideas that the teachers had to further enhance the visit for the students, and identify problems that could be addressed in the remaining class periods. At the end of the day, the teachers, scientists, and engineer met for an hour to debrief. Some outcomes of this session included:

- Eight to ten students in each classroom worked directly with a scientist or engineer (78 total students)
- Students were very receptive to help from scientists and engineers
- Passion of the scientists and engineers for STEM was evident to students

- Extra “expert” help provided strain-relief for teachers
- Having the “experts” able to refine and discuss projects that teachers did not have adequate scientific background was a great advantage for both students and teachers.
- Behavior issues of students usually prevalent in the classroom were alleviated by scientists and engineer visit
- Scientists and engineer felt frustrated with not being able to talk to and help more students due to the time constraints of the class period

Visit 2 – The testing process:

Most of the testing took place at the school during the science classes. In December 2009, two scientists and an engineer spent the entire day in the three eighth grade classrooms. Although the two scientists from the October visit were able to attend, unfortunately, the engineer from that visit had a scheduling conflict and another engineer from the lab who participated in other outreach activities came in their place. The scientists and engineer again prepared a short presentation on the testing aspects of a project they had or were currently working on.

The scientists and engineer primarily worked one-on-one with students on developing a plan for testing or performing the actual experiments. The students chosen to work with the scientists and engineer were selected by the teachers. In most cases, the students chosen were those who needed more help in deciding on a test process or those who had projects outside the teacher’s area of expertise. This also included students who had recently moved into the school boundaries and were behind in the science fair process, students who did not speak English and had to use a student interpreter, and students who had chosen projects on a high math or science level. All students were also permitted to come to the science classroom during homeroom, lunch and afterschool for extra science fair assistance. Most students being helped by the scientists and engineer during the class time and those who had not been able to get time with the scientists and engineer chose to get extra help during those times.

The teachers’ prep period between the first and third period classes was again used to go over other ideas that the teachers had to further enhance the visit for the students as well as to identify problems that could be addressed in the remaining class periods. Due to the overwhelming response from students to stay afterschool, a formal debrief did not occur; however, the scientists, engineer, and teachers came up with outcomes via email. Some outcomes for this session included:

- Six to eight students in each classroom worked directly with a scientist or engineer (47 total students)
- Students were even more receptive to help from scientists and engineer
- Students were very comfortable with the scientists and engineer since this was the second time the professionals had visited
- Scientists felt more comfortable in the classroom and with the students since this was a second visit
- Extra “expert” help again provided strain-relief for teachers
- Having the “experts” able to refine and discuss projects that teachers did not have adequate scientific background was a great advantage for both students and teachers.

- Behavior issues of students usually prevalent in the classroom were again alleviated by scientists and engineer visit
- Time constraints still prevailed as scientists and engineer were not able to help all the students who required assistance
- Scientists and engineer able to direct teachers and students to other science experts at the research lab that could be contacted for equipment or more information on the projects.

One of the most notable outcomes that resulted from the second visit was pairing some students with a scientist or engineer at the lab who had the expertise in the science area being investigated. The scientists and engineer who were participating in the classroom were able to pair up with some students, but also facilitated contact with others at the research lab as needed. For example, a thermal imaging scientist was paired with a student testing the temperature which household items burned. (An infrared thermometer from the lab was provided for the experiment.) Also, a speech processing engineer worked with a number of students on musical and noise experiments. Here, students were shown how to use audio processing software and were loaned computers to complete projects on guitar strings, frequency spectrums, harmonics of strings, and tones on balloons filled with different liquids. Scientists specializing in bioluminescence experiments were able to help students perform tests on bioluminescence properties. Students were also able to contact the scientists and engineers by phone or email through their teacher or parent. Scientists and engineers gladly provided assistance for the teachers and parents to help their student understand the project better. Some scientists and engineers met with students at school outside the standard visits to provide a deeper learning opportunity with the student being mentored. Students were surprised that the scientist or engineer would take the time out of their work schedule to help with their project.

Visit 3 – The graphing, interpretation, and presentation process:

The students were to have completed testing during the Winter Break and come back to school ready to analyze data and draw conclusions. Prior to the professional visit, the teachers had indicated that many students had not completed testing due to the student being lazy or finding out late that their test was not appropriate or did not work. The teachers requested that the scientists and engineers come with testing ideas that the students could complete in one class period. The research lab also decided to bring two scientists and engineers for each classroom to help with the project. Two scientists and four engineers spent the entire day in the three eight grade classrooms in January 2010. The new engineers who joined the group had recently graduated from college and been hired at the research lab. The young engineers were given a history of the program, but told that the main purpose of their visit was to help the students who did not have a valid project to perform and to complete testing during the class period. The scientists, who had been with the project from the beginning, prepared about 20 simple projects with materials and instructions that could be performed by the students within the class period. In the classroom, a short presentation was given by the scientists and engineers on graphing and how it is useful in the professional's work to convey data. The teachers then directed the students with no project to find a scientist or engineer to help them. Many students who had data which did not come out as expected, or had taken the data incorrectly, also chose to get help and start a new project. Three to five students in each classroom needed help for a total of 35 students throughout the day. The scientists and engineers ran out of "pre-made" projects by the

middle of the day and had to come up with experiments “on the fly “or repeat some of the previously done experiments. Some assistance on graphing was able to be provided, but most time was spent on the new projects.

Due to the frantic nature of the day, students used the homeroom, lunch, teacher preparation period and afterschool to continue work on projects and gain assistance from the scientists and engineers. The teachers, scientists and engineers finally were able to debrief the day about an hour after school had ended. Some outcomes included:

- Only 42 students were able to be helped throughout the day, with the majority of students being those who had not completed a project
- Students were receptive to the help from scientists and engineer
- Uncertain if the “frantic” experiment testing provided scientific knowledge or understanding for the student
- Students who had completed testing, but were in need of help with graphing and interpretation, did not get the help from the professionals
- Extra “expert” help again provided strain-relief for teachers
- Scientists and engineers were exhausted at the end of the day and did not feel as productive as previous visits.

Visit 4 – The oral exhibition judging visit:

At the completion of the science fair projects, students were required to provide an oral presentation of their projects to friends, family and professionals. Six scientists and engineers from the research lab, some of which had visited in the classroom, participated in the judging of the oral presentations. Students gave a five to ten minute summary of their project providing then an opportunity to use communication skills as well as to demonstrate their understanding and knowledge gained through the science fair process. Many of the students sought out the scientists and engineers prior to the presentations to ensure their mentor would be able to hear their presentation. Since the school had assigned the scientists and engineers to presentations, it did not always work out to be able to hear the student who had been mentored. The students made sure that the mentors came to see their final product in the auditorium after the presentations.

Final discussions and way forward:

After the science fair process was completed, the science teachers, principal, and one of the scientists met to discuss results of the project as well as changes and concerns for the following school year science fair process. The following table shows the data for the school and science fair process from 2006 through 2010. As can be seen, the number of students invited to the regional and state science fair competitions was increased for 2010 during the time the students worked with the scientists and engineers. The number of students declining to participate in the science fair process also decreased. Those students listed as declining to participate did not participate due to lack of motivation, coming late to the science fair process, being behind in the process or just giving up. The teachers could see changes in the students’ attitudes toward science and science fair with the inclusion of the scientists and engineers. Numerous lower

performing students, whom the teachers did not think would perform well on the science fair project, not only outperformed the expectations of teachers and families, but also showed a greater interest in science and math. A few of the students who had not been motivated until the last visit in January, were so inspired that their projects made it to the regional science fair completion.

	2006	2007	2008	2009	2010
Grade 8 Enrollment in January of:	349	341	339	296	301
Ethnicity as a percent of all					
African American	12%	14%	13%	11%	9%
Hispanic	38%	39%	36%	36%	35%
White	40%	39%	42%	44%	45%
% Title 1 qualified	45%	47%	44%	45%	42%
% Student with disabilities	12%	13%	11%	16%	13%
% English Learner	14%	13%	9%	13%	8%
Number of students invited to Regional Science Fair	76	94	101	102	111
% of grade 8 students invited to Regional Science Fair	22%	28%	30%	34%	37%
Number of students invited to State Science Fair	6	9	8	10	14
% of grade 8 students invited to State Science Fair	1.7%	2.6%	2.4%	3.4%	4.7%
Number of students declining to participate	28	22	16	12	5
% of grade 8 students declining to participate	8.02%	6.45%	4.72%	4.05%	1.66%

Even more notable than the increase in students participating in the regional science fair, were the changes in the attitude of the students, teachers, parents, scientists, and engineers. Overall, most students gained confidence in themselves and their science aptitude. The teachers found that they learned science and engineering best practices through watching the scientists and engineers interact with their students. Parents commented on the level of achievement made by their students with the help of the scientists and engineers. Scientists and engineers gained a deeper understanding of the challenges teachers face and their role in the classroom. Most scientists and engineers wanted to sign up for more events and activities in the classroom setting. Some of the comments are listed below:

From students:

- “I can’t believe a scientist took so much time to help me with my project. I had to contact her over Winter Break and she provided so much help so I could understand my data.”
- “I have always been good at math and liked my science class, but the scientists and engineers made me see that I want to be a scientists or engineer when I grow up.”
- “My sister did a science fair project before the scientists and engineers came to the help. I remember she struggled with her project. It was great having the scientists come and help out. It made the process easier.”
- “I looked forward to the people from SPAWAR coming to help.”

From teachers:

- "The S&Es from the lab provide such good role models for the students. Many have never met a scientist or engineer."
- "The scientists have been a great help at listening to what we needed. The project has been more beneficial than any of us thought possible."
- "I know I can email or call the scientists and engineers and they will find ways to assist our science classrooms."

From scientists and engineers:

- "I was really surprised at the second visit when I had a line of 10 students wanting to talk to me about their project. I felt like a rock star!"
- "It was difficult at first to figure out how to talk and relate to the students, but once I found out their interests I could help them find a project that they would enjoy."

The teachers, principals and scientist came up with the following changes and ideas for the next school year:

- Visits from the scientists and engineers greatly enhanced the science fair process and should be continued
- Bringing more than one scientist or engineer to each classroom would be beneficial
- The timing and tasks of the first two visits worked well and should be continued
- The intervention of students without projects which occurred in the third visit should be moved up to the second visit in December to provide more time for students to embrace the science fair process, rather than just quickly complete a project
- The pairing of students to scientists and engineers at the research lab should be continued and performed earlier in the science fair process

Conclusions

For the 301 eight-grade students, the results of the pilot project resulted in 111 students being invited to the regional science fair competition, 14 students being invited to the state competition and close to 100% of the students completing the science fair project requirement. The teachers and the students were very receptive to the scientists and engineers providing expertise to the science fair process. The three main objectives of the model for the scientists and engineers to 1) provide relevance to learning science and performing a science fair project; 2) provide scientific mentors to work with a limited number of students to enhance the student's learning and capability; and 3) provide the science inspiration for lower performing students to produce a successful science fair project were met.

Provide relevance to learning science and performing a science fair project:

The teachers and students could feel the passion of the scientists and engineers for STEM. The scientists and engineers brought real applications to the scientific process by demonstrating experiments and testing that they perform on a daily basis. The scientists and engineers helped validate the curriculum, textbook and teacher presentations by bringing the real world problems to the students for possible science fair projects.

Provide scientific mentors to work with a limited number of students to enhance the student's learning and scientific skill set:

The teachers found having an extra hand in the classroom helped provide more assistance and having experts in various science and engineering fields enriched the student in ways not possible by the teachers alone. The teachers noticed the attention span and desire of the student to learn the science and engineering of the project increase as the scientists and engineers participated in the science fair process. A greater percentage of projects advanced to the regional and state science fair competitions than without the scientists and engineers in the classroom. Moreover, the projects that were completed had more depth and richness not seen in previous years. The students seemed to embrace the scientists and engineers visits and were eager to gain the assistance of the professional. Student commented during their oral presentations that they were able to gather, graph, and understand their data because of the mentors.

Provide the science inspiration for lower performing students to produce a successful science fair project:

Numerous students who were not projected to perform well or even produce a science fair project surpassed the expectations of teachers and parents and completed a project. A few of those students were even invited to the regional science fair competition. The teachers saw the positive change in science and math classes from the experience with the scientists and engineers as the students were more focused and confident in these classes after science fair.

Overall, the project was a considered a success by the school administration and the teachers. One unexpected outcome was the influence on the teachers. The teachers felt that they gained more insight into science concepts and the science and engineering process by observing and interacting with the scientists and engineers. The school and the research lab have committed to continue the effort in future years. The research lab has developed a good relationship and feels part of the school community such that the lab is vested in continuing to assist the students in science fair and other projects. The recommendations from the 2009-2010 project are currently being incorporated into the 2010-2011 school year. To date, the four classroom visits have taken place and have been successful. More scientists and engineers have participated providing more students with help and guidance. The intervention for students not having projects was performed in the second visit (December 2010) and students were able to complete projects without being in a frantic mode during the end of the science fair process. The response of the students to the assistance from the scientists and engineers has been even better this year. Prior to the scientist and engineer visits, the teachers prep the students on the value the professionals bring and the students have been very receptive. The plan is to continue to refine the model and continue to bring scientists and engineers into the science fair process. In order to increase the "expert" help during the science fair process, local universities are being contacted to provide college students as mentors. A formal evaluation process is also being considered with an evaluation expert to provide a better view of the effectiveness of the scientists and engineers in the science fair process. The process is also being extended to other partner schools to expand the expertise to other science fair students.

While the science fair process is not the only method for scientists and engineers to enter the classroom, it is hoped that other schools and companies will see the benefit and relevance of this model and try similar projects. STEM professionals can provide a strong foundation of the relevance of concepts for students as well as teachers. With mentoring, students can gain deeper understanding of concepts as they are guided through a topic that is of interest to them. One recommendation to other schools and STEM professionals would be to develop a relationship prior to attempting this model. The success of this project was a direct result of the research lab and the science teachers working together on bringing speakers and demonstrations to the classroom, thereby developing respect and trust with each other prior to attempting the science fair process. While trust was being built, the teachers were able to determine how best to use the scientists and engineers. Also, the scientists and engineers were able to see how best they could provide age-appropriate material to the students. Communication between the teachers, scientists, and engineers was the key to the success of the project. Since it was the teachers' idea to bring the scientists and engineers into the science fair process, there would need to be buy-in from the teachers and administrators for the model to be a success. The model also requires a commitment from the company to commit to the school and to take recommendations from the teachers and administrators as the experts in the educational aspects of the project.

References

1. National Research Council (2007). National Science Education Standards, Washington, DC: National Academies Press.

2. Laursen, S., Liston, C., Thiry, H., and Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K-12 classrooms, CBE-Life Science Education, *6*, 49-64.

3. Seymoure, E. (2002). Tracking the process of change in US undergraduate education in science mathematics, engineering and technology. Sci. Educ. *86*, 79-107.

4. Bybee, R. W., and Morrow, C. A. (1998). Improving science education: the role of scientists. Fall 1998 newsletter of the Forum on Education of the American Physical Society. http://www.spacescience.org/education/papers/Roles_BM.pdf (Accessed 26 August 2009).