AC 2009-934: PROMOTING SCIENTIFIC INQUIRY THROUGH INNOVATIVE SCIENCE AND ENGINEERING CURRICULA IN GRADES 3-5

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Introduction

Technological and scientific literacy are crucial for students to compete in the global economy of the 21st century\textsuperscript{1,2}. The widening gap in math, science, and engineering achievement between the students in the U.S. and those in other developed countries is partially due to teachers lacking content knowledge, pedagogy, and experience in these subjects\textsuperscript{3}. Now in its second year, the Partnership to Improve Student Achievement (PISA), a state-sponsored Math-Science Partnership (MSP) program, is providing 47 grade 3-5 teachers in urban districts of New Jersey with high quality, research-based, innovative science and engineering curricula, classroom-focused professional development, and mentoring designed to address topics in key content areas in science and technology education. Scientific inquiry and the engineering design process are the two vehicles that are being used in our activities to promote teachers’ content and pedagogical knowledge and increase students’ achievement and engagement in science. The partnership includes six urban districts in northern New Jersey, a science center, teacher education institution, and an engineering college. Teachers receive a two week summer institute, one hour monthly classroom support visits, and three professional development days during the school year. The goals of PISA are: (1) to increase teachers’ content knowledge in specific science topics and engineering, (2) to improve the teachers’ notions of scientific inquiry, (3) to increase participating teachers’ preparedness in creating, adapting, and delivering inquiry-based science and engineering lessons, and (4) to increase students’ content knowledge in specific science topics and engineering. This paper will focus on the data collected from teachers regarding the second goal of this project, which is improving the teachers’ notions of scientific inquiry. Future papers will focus on findings that will address the other goals.

Each year of the PISA program focuses on a different science discipline with corresponding technology and engineering lessons. The first year was devoted to life and environmental sciences, earth and space sciences this year, and physical sciences next year.

During the two-week summer institute held in 2008, teachers learned earth and space science content through lectures, hands-on activities, field trips, webquests, collaborative work, reflections, model-based inquiry, and the engineering design process administered by the faculty and staff of the engineering and teacher-education colleges. Science activities were based on the notion of scientific inquiry from the National Science Education Standards\textsuperscript{3} and the model-based inquiry framework\textsuperscript{4,5}. For instance, teachers reviewed and learned “the reasons for seasons on Earth” by drawing their expressed models, using physical models (Styrofoam balls), and explaining how the different seasons occur on Earth. Using their prior conceptions that were expressed in their naïve models; they went through series of activities using physical models, computer models, experiments, and expert’s perspective (guest professor). At the end of the lesson, they
presented their consensus model in font of the class that best explained their groups’ expressed models (see Fig. 1). After a series of different model-based inquiry lessons, teachers started to develop or revise lessons as part of their learning module. Their lessons were based on an earth or space science topic using the model-based inquiry framework.

Figure 1- Teacher presentation

Aside from science inquiry, teachers went through two Engineering is Elementary (EiE) modules over the summer to learn the engineering design process. The first module was the Sticky Situation where they learned about different earth materials and designed their own walls. The second module was Catching the Wind where they studied weather and designed their own windmills. A scientist helped teachers in their understanding of earth materials and their properties. Teachers then applied this knowledge to the creation of their own mortar for walls they constructed (see figure 2). Another professor showed them how wind can be measured and how it can be used for energy.

Figure 2

Classroom support visits were another component of the program intended to ensure success of the teachers in implementing what they learned over the summer to their
classrooms. Visits were also used to document and assess the needs of teachers and students. Moreover, three workshops were conducted during the school year to continue and reinforce the professional development that started over the summer. By the end of the second year of the PISA program, teachers will have received in-depth, content specific, pedagogical support, 124 hours of continuous professional development, and ongoing classroom support (coaching, modeling, curriculum alignment, and planning) by project partners. PISA aims to address the challenges presented by the *Rising Above the Gathering Storm*\(^1\) report which recommends teacher educators, researchers, and policy makers help teachers improve the quality of science, technology, and engineering education in the U.S. and better prepare students for the 21\(^{st}\) century.

**Background**

Current indicators are worrisome. The most recent international comparison study done by the Trends in International Mathematics and Science Study (TIMSS) in 2007, showed that math scores of U.S. 4\(^{th}\) and 8\(^{th}\) graders have increased but science scores have remained unchanged since 1995\(^7\). The National Assessment of Education Progress (NAEP) reported in 2006 that while science learning among fourth graders increased since the survey was last administered, this was not the case for students in grades eight and twelve\(^8\). These results were partially due to teachers lacking the content knowledge, pedagogical knowledge, and experience to teach the subject, lack of coherence in preservice and professional development programs offered to teachers, and students spending more time learning a greater breadth of topics and fewer topics in depth\(^1,9,10,11\). Alarming trends from the *Rising Above the Gathering Storm*\(^1\) and the *America’s Perfect Storm*\(^12\) policy reports showed that: (1) there are not enough students in the science, technology, engineering, and mathematics (STEM) fields today to support the workforce of tomorrow, (2) the number of science and engineering degrees awarded in the U.S. had fallen by 20\% compared to 1985, (3) the number of engineering graduates in the U.S. today is one-fifth the number of graduates in India and less than one ninth the number in China, and (4) there are not enough qualified K-12 STEM teachers to meet the needs of the changing population of students\(^1,12\). Addressing these needs is important for the U.S. to compete to the global workforce of tomorrow.

These concerns challenge teachers and policy makers to improve teaching, learning, teacher preparation programs, and professional development programs in STEM disciplines\(^9,10,13,14\). Teachers play a major role in the classroom. They have the ability to create and mold the environment where students can learn\(^15\). Teachers’ disciplinary content knowledge can have influence on instructional practice\(^16,17\). Unfortunately, inequalities in instruction and qualifications of teachers and resources result in widely different learning opportunities for different students\(^14\). In 1999, between 23\% and 29\% of middle and high school mathematics and science teachers lacked qualifications or did not have the academic background in the subject they were teaching\(^1\). Most teachers teaching engineering as part of a K-12 curriculum lacked knowledge about what engineering is and how they might teach the subject\(^1,18\). At the same time, most teachers attended only few hours of professional development programs and most programs
available to teachers lacked the content, continuity, and depth to make meaningful changes in their teaching practices.9,10.

To address these challenges, several programs including PISA developed professional development workshops to increase the content knowledge, pedagogy, and experiences of teachers and students in STEM disciplines. Participating teachers and students in the PISA program in year 1 increased their content knowledge in specific life and environmental science topics and engineering compared to the comparison group as a result of the program. The professional development model, based on collaborative efforts, multiple levels of instruction, and different levels of discourse, also helped teachers connect theory to practice.18. PISA stemmed from the Engineering Our Future New Jersey (EOFNJ) initiative that was launched in 2006. EOFNJ’s objective was to promote grade-appropriate engineering and technology in K-12 schools in New Jersey. Results of the pilot study done in 13 elementary schools in 2006 using two EiE6 modules (Water, Water, Everywhere and Catching the Wind) showed that students’ (1) significantly improved their ability to identify examples of technology and engineering, (2) significantly improved their ability to answer questions about water filtration, and (3) improved their ability to answer questions about windmills and blade materials.19. In a similar study, 126 eighth grade students enrolled in science classes were exposed to the engineering design process to learn concepts about water resources. The treatment group was compared to a group of students who learned the same topic through a traditional approach of teaching that involves lecturing. Results indicated that students in the treatment group who used the engineering design process showed greater content knowledge and displayed higher levels of thinking on open-ended questions compared to the comparison group.20. These research projects showed positive effects of integrating engineering and technology in science for both teachers and students.

Methods

The second PISA summer institute was held in the summer of 2008. The project started with 35 teachers from year 1 of the project and 13 new teachers. Unfortunately, one teacher was forced to withdraw from the project after being ill for several days. In the end, 47 teachers of grades 3-5 from 18 public and 3 non-public schools in northern New Jersey completed the workshops over the summer. The participating teachers included classroom teachers, inclusion teachers, special education teachers, and a computer technology teacher. Several teachers in year 1 did not continue in year 2 for a variety of reasons (e.g. reassignment to teach grade levels other than the scope of this project, moving to a different school, etc.).

Three instruments were developed to determine the extent in which the teachers’ notions of inquiry change over one year. These instruments were (1) a notions of scientific inquiry pre-survey, (2) a learning module science survey, and (3) a classroom observation protocol. The scientific inquiry pre-survey was given to teachers on the first day of the summer workshop to capture the teachers’ pre-instructional notions of inquiry. The learning module science survey was given at the conclusion of the two week workshop to capture the teachers’ notions of inquiry after instruction. Lastly, the classroom
observation protocol captured what and how teachers implemented their inquiry lessons in their classrooms. These surveys and observation protocol were adopted from the work of Windschitl and the National Science Education Standards. In addition to observation protocols and surveys, classroom artifacts and filed notes (lesson plans, hand-outs, students’ work, pictures, etc.) were collected during classroom visits. An elaborated discussion of findings from these data will be presented in the next section.

Results

Teachers’ notion of scientific inquiry in pre-survey

Workshop instructors were asked to rate the teachers’ levels of competence (high-moderate science content knowledge, some science knowledge, little or no science knowledge but willing to learn, and no science knowledge) because it seemed likely that teachers’ levels of competence would correlate with the extent to which they considered their classroom inquiry-based. The first question on the survey asked to what extent the teachers felt their science classrooms could be described as inquiry-based classrooms. Almost 50 percent felt that this was only “somewhat” the case. However, there was no statistical correlation between the instructor’s rating of the teachers’ competence as science teachers and the teacher’s rating of their classrooms as inquiry based. Although it was notable that those with little or no science knowledge were more likely to see their classrooms as inquiry-based than those with more knowledge (see Figure 3). In addition, there was no correlation between the teachers’ years of teaching experience and their ratings of their classrooms as inquiry-based.

![Figure 3](image_url)

The survey asked the teachers to indicate the frequency (most of the time, a lot of time, limited amount of time, and never) with which they would ideally like their students to participate in science class activities and compared the results to the actual frequency that these activities were done by teachers. Results indicated that the majority of teachers felt that they need to change the way they teach to make their classroom more inquiry-based. Specifically, they wanted to do more of the following with students: brainstorming in the beginning of a unit, reflecting on their own work, making thinking visible through models and modeling, making sense of data, sharing ideas with others, and using
evidence to support their conclusions. There was only one item in which the majority of teachers felt that they did not need to change and that was “students working individually.”

In the question: “In your own words, describe what a science class is like when students are doing inquiry” teachers’ answers to this question fell into three major categories- the format of the class, the source of inquiry question, and the process of scientific inquiry. Over two-thirds of the teachers (69 percent) did not specify the format of the class. Most of the rest (29 percent) described the ideal class as working in groups. Sample responses included:

“I envision inquiry in a science class as children engaged in small group discussion.”

“Students…are in groups and they are discussing and sharing ideas with one another.”

“There is a small group of students utilizing several objects to solve a problem.”

Only one person said it could be either in individual work or in group work and none described individual work. Many of the teachers (46 percent) also included descriptions of the students’ interactions with each other in the class:

“…brainstorming together, discussing/ working together.”

“Discussion and cooperative learning is the key to success.”

“The students are quiet first. Later, when an idea comes out and contradiction gets it, the class becomes interactive…”

There were six codes generated for the source of inquiry question. They were teacher generates question (guided inquiry), students generate question (independent inquiry), both guided and independent inquiry, unspecified who generates question, implies a question, and no question. About one-third of the teachers (33 percent) wrote that the students would generate questions for the inquiry.

“Students…asking questions to themselves or to the other students to find the best solutions”

“…they're asking questions and trying to use any prior knowledge”

“Students are forming their own questions about a particular science topic, and then designing investigations of their own.”

Only a few teachers (6 percent) wrote that the questions would be generated by the teacher, by both teachers and students (4 percent), and about one-quarter (24 percent) did not specify who should generate the inquiry question (see Figure 4).
Based on the model response generated by one of the project instructors, the process of scientific inquiry was broken into ten steps (see Figure 5). Only a few teachers (14 percent) came close of including the first step (A), where students generate naïve models as part of the process of scientific inquiry. However, they were generally referring more to eliciting prior knowledge than to generating actual models. One-third (33 percent) included students developing hypotheses that can be tested experimentally (B). About half of the teachers (53 percent) included the idea that students will conduct a series of observations or experiments using different techniques or approaches (C). Only a very few (4 percent) included students analyzing data (D) and wrote that they would explain the results based on science (E). None of the teachers mentioned the final parts of the inquiry process: (F) students revise models, (G) students present a consensus model, (H) students conduct additional experiments, (I) students further revise the model, or (J) students present final model. When combinations of steps in the inquiry process were analyzed, we found that the most commonly listed step (C—observations/experiments) was most frequently combined with B (developing hypotheses), and less frequently with A (generating naïve models) and D (analyzing data).

A follow-up open ended question in the survey asked the teachers to describe the reasons what they felt were most responsible for the discrepancies between the ideal and actual amounts of time they had reported in terms of teaching science. Teachers’ responses to this question fell into 5 categories and the categories were: student population, time and test prep issues, limited resources, curriculum-related challenges, and policy/leadership
expectations. Teacher perceived challenges related to student population included different ability-levels of students, behavioral/discipline problems, not used to scientific inquiry, lack of collaborative working skills, special education students, class size, and lack of parental support. Time and prep issues were brought by the standardized exams and districts’ curricula that were focused in language arts and mathematics. Limited resources included money, materials, space, and support. Curriculum related problems were limited, outdated and difficult science curriculum curriculum. Lastly, teachers received a variety of support and expectations from their schools’ administrators.

*Teachers’ notion of scientific inquiry after the summer workshops*

The question on the second survey asked the teachers to describe the process of scientific inquiry. Since this question did not ask them to describe a class, the organization of the class was not included in the analysis of the responses. The other two categories were the same as in the analysis of the first question - the source of the inquiry question and the process of scientific inquiry.

We used the same six codes for the source of the inquiry question (see Figure 6). In this case, about the same number of teachers (17 percent) wrote that the questions were mainly generated by the teacher and 15 percent wrote that they were mainly generated by the students. Only a very few teachers (6 percent) wrote that questions were generated by both the teacher and the students and many teachers (34 percent) did not specify who should generate the inquiry question.

“Inquiry is when a question is presented.”

“The process of inquiry starts with a question about known concept or process....”

Several teachers (4 percent) gave answers that were ambiguous in terms of whether a question was involved. Even after several days of discussing inquiry, almost one-quarter (23 percent) of the teachers did not include any mention of questions. Instead, they focused on a different phase of the inquiry process, this time with more reference to the preceding phase of modeling, which had been discussed at length during the workshop, as well as the subsequent phases of observing and experimenting:

“Scientific inquiry begins with the creation of an initial model.”

“Scientific inquiry allows students to ‘do’ or ‘discover’ science, rather than simply listen to or read about science.”

<table>
<thead>
<tr>
<th>Coding Scheme</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher generates question (guided inquiry)</td>
<td>8</td>
<td>17%</td>
</tr>
<tr>
<td>Students generate question (independent inquiry)</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td>Both teacher and students generate questions</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Unspecified who generates question</td>
<td>16</td>
<td>34%</td>
</tr>
<tr>
<td>Implies a question</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>No question</td>
<td>11</td>
<td>23%</td>
</tr>
</tbody>
</table>
Regarding the process of scientific inquiry, the same steps were used in the analysis. The numbers and percentages were as follows:

<table>
<thead>
<tr>
<th>Coding Scheme</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students generate naïve models (initial conceptions) (A)</td>
<td>25</td>
<td>53%</td>
</tr>
<tr>
<td>Students develop hypotheses to test experiments (B)</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td>Students plan investigation I</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td>Students conduct a series of observations or experiments, using different techniques or approaches (D)</td>
<td>39</td>
<td>83%</td>
</tr>
<tr>
<td>Students analyze data (E)</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td>Students explain results based on science (F)</td>
<td>11</td>
<td>23%</td>
</tr>
<tr>
<td>Students revise their models based on data (G)</td>
<td>20</td>
<td>42%</td>
</tr>
<tr>
<td>Students present consensus model (H)</td>
<td>10</td>
<td>21%</td>
</tr>
<tr>
<td>Students conduct additional experiments (I)</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td>Students further revise the model (J)</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Students present final model (K)</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

In this response, a much larger percentage of teachers (83 percent) focused on having students conduct a series of observations or experiments, using different techniques or approaches (D):

“Children…answering questions through scientific experiments, research of data, etc.”

“The child will then proceed to observe, gather data, and explain.”

“Scientific inquiry is the process by which students are constructing knowledge…through…hands-on activities.”

“It is discovery learning that is student directed through the use of models (physical, visual, etc.) Scientific inquiry drives content and scientific practices like observations…”

A much larger percentage of the teachers (53 percent) than on the first survey also included the step where students to generate naïve models (A). In addition, although there continued to be some confusion between eliciting prior knowledge and actually constructing a model from that knowledge, the word “model” was used much more frequently. And many more (42 percent) included the step where the model is revised based on data:

“Revision of the model will take place…”

“Edit model and add new ideas to concept.”

“Make adjustments to show understanding.”
About 23 percent of the teachers included the step where student explain results based on science (F) and 21 percent of the teachers included the step where students present a consensus model. However, only 15 percent of the teachers wrote about students analyzing data (E) and only 9 percent included the step where students develop hypotheses to test experiments (B).

When combinations of steps in the inquiry process were analyzed, we found twenty-seven different combinations. Almost half the teachers (45 percent) included at least steps A and D: they had students generate naïve models (A) and conduct observations or experiments (D), with some including one or another step as well.

*Comparing the Notions of Scientific Inquiry: Before and After*

When we compared the answers that look at the source of inquiry question and the process of scientific inquiry in the first and second survey, we found that more teachers had the students generating the inquiry question on the first survey and more had the teachers generating the question on the second survey. In addition, more teachers did not specify who generates the question on the second survey. It seems likely that this was because by the time of the second survey was given; teachers were more focused on the issue of generating models than on generating questions (see Figure 8).

<table>
<thead>
<tr>
<th>Source of Inquiry Question</th>
<th>Survey #1</th>
<th>Survey #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher generates question (guided inquiry)</td>
<td>6%</td>
<td>17%</td>
</tr>
<tr>
<td>Student generates question (independent inquiry)</td>
<td>33%</td>
<td>15%</td>
</tr>
<tr>
<td>Both guided and independent inquiry</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Unspecified who generates question</td>
<td>24%</td>
<td>34%</td>
</tr>
<tr>
<td>Implies a question</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>No question</td>
<td>24%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Figure 8

In addition, teachers’ descriptions of the process of inquiry were much more comprehensive on the second survey compared to the first. There was a notable increase in step (A), where students generate naïve models (from 14 percent to 53 percent); step (C), where students conduct a series of observations or experiments (from 53 percent to 83 percent); step (D), where students analyze data (from 4 percent to 15 percent); step (E), where students explain results based on science (from 4 percent to 23 percent); step (F), where students revise models (from 0 percent to 40 percent); and step (G), where students present a consensus model (from 0 percent to 21 percent). At the same time, the number of responses that did not mention any of the steps in the inquiry process decreased (from 31 percent to 6 percent). On the other hand, there was a decrease in step (B), where students develop hypotheses to test experiments (from 33 percent to 9 percent).

*Model-based inquiry in the classroom- Highlighting One Class of 3rd Graders*
Preliminary data from artifacts collected in the classrooms showed that more than half of participating teachers implemented and tried to use model-based inquiry in their teaching. For instance, a class of twenty nine 3rd graders went through a lesson that examined the causes of the different seasons on Earth. Working together, the teacher and the project instructor looked at students’ work and evaluated the students’ models, which contained drawings and explanations of their understanding about the topic. Students’ expressed models were coded as 0 if there was no, little or incorrect understanding (Fig.9), 1 if there was some understanding and students were able to make a representation but cannot explain or have incorrect explanation (Fig. 10), 2 if there was a better understanding and students were able to identify the parts of the model but unable to make connections (Fig. 11), and 3 if students provided an accepted model and explanation (Fig. 12.).

Analysis indicated that in the beginning of the lesson, 27 students were at level 0 and only 2 students were at level 1. Most students could identify the different seasons and its effects but couldn’t explain why the seasons occur. Specifically, students mentioned that seasons were caused by the solar system, the movement of Earth around the sun, the different continents, etc. Only 2 students mentioned the tilt of the Earth but failed to explain how it can cause the different seasons. After eliciting students’ preconceptions about the topic, the teacher implemented hands-on activities (guided by content done during the 2008 summer workshop) to improve the students’ understanding. She used physical models (Styrofoam balls, flashlight, globe, etc.), computer models/simulations, and observational experiments to teach the different science concepts about the topic. Then she asked the students to revise their expressed models individually. Based on the analysis of students’ revised expressed models after the first lesson, 7 students remained at level 0, 19 students moved from level 0 to 1, 1 student moved from level 0 to 2, and only 1 student moved from level 0 to 3. It is very interesting to note that the 2 students who started at level 1 remained in the same level after the first lesson. In general, at the end of the first lesson, most students drew the tilt and the positions of the Earth relative to the Sun but still failed to explain how the seasons occur. Students’ drawings improved from their first one but lacked the explanation to support their drawings. The teacher said that this was a learning experience for her to see that her students still can not fully explain a science phenomenon even after a well-planned lesson.
Figure 9 Example of Level 0- no, little, or incorrect understanding (Naïve model, Student E)

Figure 10 Example of Level 1- Some understanding. The student can make a diagram/representation but can’t explain or has incorrect explanation. (1st revised model, student C)
Figure 11 Example of Level 2 - Better understanding. Students can identify the parts of the model but can’t make connections (diagram/representation and explanation). (1st revised model, Student A)

Figure 12 Example of Level 3 - Accepted model and explanation. (1st revised model, Student Z)
Preliminary data from artifacts collected from the participating classrooms indicated that students enjoyed engineering design challenges and were motivated to learn science because of them. They loved the competitions to design the best windmill that catches the wind or to create the strongest wall that could stand a hit from a swinging golf ball. In the process, they learned the engineering design process of asking questions, brainstorming ideas, planning, creating prototypes, testing, and re-designing products.

Lessons Learned and Next Steps

Technological literacy as well as scientific literacy are crucial 21st century learning goals for students. For literacy to be achieved in both areas, intensive and ongoing teacher professional development programs and classroom support are needed to foster teacher’s content knowledge and to change classroom practices. The PISA project in year 1 showed evidence of increased content knowledge and classroom practices in science and engineering as a result of collaborative efforts from project partners, multiple levels of instruction, and a variety of methodology to develop an effective professional development program\(^9\text{,}\text{10,}\text{19}\). Furthermore, the year one study indicated that the students of teachers participating in the PISA program had gains on life science and engineering content more than two and a half times greater than students of teachers in a comparison group\(^19\). Similar to the findings of Justi & Gilbert\(^22\), our data for year two so far has shown improvements in teachers’ notions of scientific inquiry. The PISA participant teachers were more comprehensive in their description of scientific inquiry after attending two weeks of summer workshops. Specifically, there was a notable increase in their identification of scientific practices such as generating models, conducting a series of observations or experiments, analyzing data, explaining results based on science, revising models, and presenting models. The unintended results of focusing the summer workshops on models as part of scientific inquiry were teachers’ uncertainty of the source(s) of the inquiry questions and less emphasis on formulating hypothesis.
However, we believe that the advances that our teachers made during the workshop outweighed the unintended results that were found. Congruent to the findings of Windschitl, our participant teachers had limited notions of inquiry in the beginning that were focused on hands-on experimentation and based on the traditional scientific method. Unlike the works of Schwarz & Gwekwerere and Windschitl, our work was done in a professional development setting and not in a pre-service science program. Teachers’ challenges in meeting the ideal inquiry-based classroom included diverse student populations, time and test prep issues, limited resources, curriculum-related challenges, and a variety of policy/leadership expectations.

Preliminary analysis of artifacts from the classroom suggests that teachers and students learned from model-based inquiry and the engineering design process. Students were motivated and excited to learn because of the engineering design challenges. Lachapelle found similar positive results of using EiE modules with elementary students in N.J. Though we are not ready to show connections between earth and space science content knowledge and engineering design process at this point, we are hoping to add to this field of research by the end of year 2, in-line with the work done by Riskowski et al.

Our future work is to analyze additional data collected during the 2008-2009 school year that will address the project’s goals to (1) increase teachers’ content knowledge in specific science topics and engineering, (3) increase participating teachers’ preparedness in creating, adapting, and delivering inquiry-based science and engineering lessons, and (4) increase students’ content knowledge in specific science topics and engineering. This effort will include administering post-tests to teachers and students in May 2009, analysis of pre and post tests, analysis of science and engineering classroom observation protocols, and analysis of classroom artifacts (teacher lessons, culminating project, etc.). From these data, we are hoping to learn if there are any changes in the content knowledge of teachers and students in science and engineering, and to capture the teachers’ implementation of the engineering design process in the classroom.

Bibliography