Evaluation of the Museum of Science PCET Program

Interim Report: Draft

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Executive Summary

The following report presents the findings from the evaluation research conducted by Davis Square Research Associates (DSRA) for the Boston Museum of Science PCET (Pre-College Engineering for Teachers) project, with a focus on the series of summer workshops conducted at three sites (Tufts University, UMass-Lowell, and Worcester Polytechnic Institute) during the summer of 2007. This part of the NSF—funded project seeks to improve the participants' understanding of engineering and their capacity to teach engineering concepts and methods in elementary school classrooms.

Key findings include:

1. Participants improved in their knowledge of, and attitudes toward, engineering for teaching
2. Participants judged the Engineering is Elementary (EiE) materials to be of high value and likely to be very well received by students
3. Participants gained in their confidence in teaching engineering
4. Participants expressed considerable eagerness to begin the implementation of engineering units

Sample & Method

The sampling frame for the report is coextensive with the participants in the summer program (N=162). Further information on the participants and activities will be found in the project report.

The evaluation method relies upon one online survey and three focus groups, developed by DSRA in collaboration with the PCET project management team. Rather distinct from previous surveys, the current survey relied somewhat more heavily on qualitative data gathered through open-ended questions. These data were gathered online, then downloaded by DSRA for analysis in SPSS.

All focus groups were conducted at the Tufts site. These data were transcribed and then analyzed by DSRA using HyperResearch.

The key questions for the survey were:

- What were the effects of participation in PCET on participants' knowledge, attitude, and instructional practices around engineering content?
- What are the responses to the participants to the EiE material?
- What are the prospects for implementation of the engineering units?
- What other effects of participation can be attributed to PCET?

Survey Findings

In this section DSRA presents the findings from the survey. The first section presents the data from all respondents, from all workshop sites, in aggregate form.

When asked for a general response to what worked well in the workshop, participants quickly established a pattern that would hold true throughout the survey. This pattern can be characterized as tremendously positive, with the areas of appreciation roughly divisible into three areas. These areas are (1) more or less specific learning gained through interactions with other teachers, presentations, and the EiE materials, (2) an appreciation for the workings of the professional development activities, and (3) reported changes in awareness, attitudes, and behavior. For the first responses to the opening question, DSRA has taken created three categories of utterances. It should be noted that these categories are not so much watertight conceptual acts, as they are a way of making sense of the general trendlines in the responses.

Table 1: Sample of Participant Reactions to the Workshops

Interactions	Activities	Learning
• Interaction with other teachers; having the units presented by teachers who had already taught them. • I enjoyed the interaction of the teachers and logical and creative thinking skill that were used when working with the hands-on projects. • Working in groups trying the lessons/activities (i.e. building bridges, windmills and water filters). • I enjoyed being in the company of same grade teachers so that ideas that were shared were things that we could actually use. • Understand the challenges. • Working on the projects in teams, looking at the binder materials, listening to the staff who have done the units, having an engineer available to answer questions and give suggestions • I meet many teachers who shared many great ideas. I received a lot of background information to assist me when I teach these units.	• All of the "hands on" activities • I liked that we got to try out the different activities. • It was great to be able to experience the hands on activities for many of the lessons as this really helps to think through the way it will work with students. • This was one of the best workshops I've ever attended. It was a great mix of listening and doing. The opportunities to go through the binders and work out each lesson were invaluable. Teachers never have that kind of time to experience it themselves! • I liked the flow of the workshops. Lecture, or listening activities were mixed with hands-on lessons that broke up the day and kept it interesting and fast-moving. • The hands on activities and the freedom to make mistakes refine and retest • Doing the various activities, gave me confidence to try them in my own classroom. Having several of them showcased gave me a good indication of what they were about.	• The explanations of units. The trial and error on our parts to see how they could fit into our curriculum and grade level. The consistency of the scientific method stages/stages of inquiry and how it ties to D.O.E. standards/learning strands. Having the "theory" of the units taught by engineering expertise, as opposed to this is how to do the unit with no theory foundation, which was my whole purpose in taking the course. • I left the training with a new respect for the field of engineering. • I enjoyed learning about engineering and discovering that it's not some scary, difficult subject, only for the elite. • It was great to have a college engineering professor lead the program; loved touring the plastics labs; loved trying out the units; loved learning background information about U Mass Lowell North campus; loved the ground water experiment at the Boot Mill and the tour of the water turbine. It was a very worthwhile week.

When asked for the judgments on the EiE materials, participants were overwhelmingly positive in their responses. In Table 2 below, note not only the very high mean values, but also the very low standard deviations (SD), indicating a significantly (Kolmogorov-Smirnov) higher than expected level of consensus among the participants. This is a remarkably strong finding, especially in the light of the highly diverse group of teachers responding to the questions.

Table 2: Participant Assessments of EiE Units

Using the scale, please let us know whether you agree or disagree with the following statements about the EiE curriculum.	**M**	**SD**
EiE units are well designed.	6.59*	.802
EiE units fit into my required curriculum, rather than being "one more thing" to teach.	6.31*	.962
EiE units are well matched to my level of students.	6.13*	1.215

*Significant @ $p<.05$ (K-S)
Scale: 1=Greatest disagreement; 7=Greatest agreement

When asked to expand on their responses to the questions on the quality of the EiE units, teachers declared that the materials are an excellent fit for elementary school students and teachers. The qualities more often cited are the hands-on approach used by the units, the strongly sound pedagogical design of the units, the ease with which they can be adapted to fit local circumstances, the collaborative nature of the activities, and the many ways in which using the units promotes a greater awareness of the ubiquity of engineering in the lives of the students.

Of some concern for respondents was the length of time required to do the lessons, the acquisition and management of material resources to support the lessons, and the reading level of the EiE stories.

Table 3 below offers a sampling of participant responses to a question on the strengths and weaknesses of the EiE units.

Table 3: Sampling of Participant Comments on EiE Units

Good Match	Challenges to Match
• The EiE units are interesting and engaging learning experiences. I feel that the concepts are appropriate for my age group. The engineering concepts feed on the natural curiosity of my young "engineers." I also like the clear-cut design and scaffolding of the units. • I thought most of the units were developmentally appropriate. The literature may be a little lengthy and I may need to play around with the management piece, but overall I see the units as highly motivating for students. • There are a lot of strengths. Using a story to introduce the unit and the big activity at the end are two important parts. Adding a parent component may help justify the time spent on the units. • I could easily integrate the design process into many aspects of my classroom. I liked the way you do some mini experiments before designing the challenge project. I also like the way the challenges depend on cooperative groups which reinforces the importance of group work to get things done. • The bridge building unit will fit in with my curriculum very easily. I already do bridge building with my students during the first chapter of the science book. I will expand on this activity using EiE using the bridge building unit. The strengths of the units are the hands on activities. These activities are directed at all learners and will come in handy in my diverse classroom. • I think the units are well designed. I'm looking forward to trying them out in my classroom. As you know, finding the time is always a struggle. This type of hands-on curriculum is very developmentally appropriate for most first graders.	• I think that the literature connection provided for each unit is valuable but would love to see more grade appropriate picture book-style books in the future. Attention can be a problem at that age. • I can work a unit into my overfilled curriculum, but there are a lot of activities, set up and take down time, and materials to store in my overstuffed classroom. Just having the knowledge from this course will help me present things differently to the students, and help them to get a little more into engineering. • It is a challenge to fit them in an already "packed" curriculum, but the activities are so well-planned according to ability level, group size, etc., that I think they should be successful! It is such a dilemma. We have to cover so much curriculum in a short span of time. On the other hand, children learn and remember the material better when they are engaged in activities rather than just taking notes, completing worksheets and reviews, and taking assessments. • Some of the projects (bridges for example) seem too involved and lengthy to realistically fit into our already jam packed curriculum. However, I think they would make for great after-school or summer enrichment programs! • They are a bit lengthy. They require prior knowledge, so on top of teaching the lesson, you have to add 2 other weeks to do the EiE unit. Elementary teachers are very pressed for time. However, I do think that it is a wonderful program. I think it is very important that kids learn engineering. It helps them in all areas of school. It also allows them to think outside the box, which they need to learn how to do.

Participants were asked a series of questions on how well the workshops met their goals. In Table 4 below, DSRA presents these data. Note again the very high mean values, the very low standard deviations, and the consistent finding of statistical significance (K-S statistic). It is difficult to envision of series of workshops achieving a greater level of success across such widely varying groups.

Table 4: Participant Judgments of Workshop Success

Using the following scale, how well did the PCET workshop meet the following goals?	**M**	**SD**
The EiE units and materials were presented in a manner so I feel comfortable using them in my classroom.	6.61*	.653
The workshop provided strategies for doing engineering in my classroom (assessment, classroom management).	6.40*	.817
The workshop prepared me so I feel ready to do an engineering design project in my classroom next year.	6.68*	.585
The workshop allowed me to learn by doing.	6.89*	.371
The workshop gave me sufficient introduction to the MA Technology/ Engineering State Frameworks.	5.87*	1.182
The workshop had a good balance of speakers, long projects, shorter activities, and discussions.	6.37*	1.089
The workshop was well planned.	6.18*	1.298

*Significant @ $p<.05$ (K-S)
Scale: 1=Greatest disagreement; 7=Greatest agreement

Of particular interest to the evaluation research was any gain in knowledge among the participants. Given that the administration of pre-post testing was not feasible, DSRA relied on self-report (Table 5 below). These data are once again very strong, with low mean values and consistent levels of statistical significance (K-S).

Table 5: Participant Reported Gains in Knowledge

How much has your knowledge and understanding of the following improved as a result of PCET?	**M**	**SD**
My knowledge of the range of engineering disciplines	3.69*	.573
My knowledge of what engineers do	3.68*	.627
My knowledge of the pervasiveness of engineering in our society	3.64*	.665
Understanding that there is not necessarily one "right" answer for engineering problems	3.47*	.850
My knowledge of the MA technology/engineering frameworks	2.75*	.827
My knowledge of the engineering design process	3.59*	.636
My knowledge of the types of constraints that influence the design and selection of engineering criteria	3.30*	.771
My ability to analyze engineering solutions that my students may come up with	3.17*	.719

Significant at $p<.05$ (K-S)
Scale: 1=Not at all; 2=Slightly; 3=Moderately; 4=Greatly

Teachers were asked how their awareness of engineering had changed through participation. The responses were very positive once again, with only a handful of respondents reporting no change. The reported changes were divided, again very roughly, into two categories. The first category captured responses that referred to general changes in awareness. These responses tended to speak of a widening of the respondent's consciousness of the work of engineers in the world. The second category was reserved for responses that made reference to a change in attitude toward engineering, or some change in behavior readily associable with participation in the project. Table 6 below presents a sampling of responses for these two categories.

Table 6: Sampling of Participant Responses

Awareness	Attitude & Behavior
• It has enhanced my understanding of engineering and technology by exposing me to many real life situations where engineering is employed. • I am more conscious of how and where engineers have made their mark and that the range of designs and solutions is immeasurable. • This workshop has made me more aware of the improvements that engineers have made and could make in our world. As a result of this workshop I not only gained a greater understanding of engineering and the design process but now I also have a new appreciation for recycling plastics! • I hadn't realized how engineers influence so many different aspects of our everyday lives. It will be interesting to present this information to my students and to let them know what kinds of opportunities are out there for them in the world of engineering and technology. • It has broadened my perspective on engineering and the importance of introducing it to children in the classroom. • I had a very narrow view of what engineering and technology was. but PCET has "opened my eyes." • My dad was an engineer (Mechanical/Project). I feel that after this workshop I more deeply appreciate the work he did.	• I have become a bridge fanatic! I was able to go home and explain my projects to my 4-year-old son, who was fascinated. • I was quite ignorant before the workshop. I am observing technology and design all around me know. I feel excited to bring this knowledge to the classroom. • I really step back and look at things more closely and see how it relates to what we learned at the workshop. I found I talked to my family about this quite often when the workshop was finished. • I never looked at the world as full of engineering projects. Since the class I have seen the world differently...seeing engineering projects everywhere. • I am better able to explain (or attempt to) even complex engineering and technological concepts. • I will analyze different types of objects that I am surround by in my everyday life. • It certainly has. I often wonder how a bag of coffee beans ended up on the shelf at the supermarket, how a bridge was built in the water, etc. This course made me realize how much thought and often collaboration goes into designing and creating things. I think the workshop makes one wonder more and ask more questions. • Yes, I never stopped to think how almost everything (except nature) around us has been influence or touched in someway by the engineering process. It also made me excited to introduce engineering as a career path to all students but specifically girls.

When asked how participation in PCET has changed the way they teach, participants made reference to both specific and generalized effects. Table 7 below offers a sampling of responses. Note that the transition from specific to general effects does not appear to be especially challenging, an indication that PCET participation may “ripple out” to affect other classroom practices in other content areas by the same teacher.

Table 7: Sampling of Participant Responses to Teaching Changes Question

Specific Effects	Generalized Effects
• I will emphasize the process as a major component of any project. In first grade, the kids just want to jump in. This will really help me show them how important planning and testing are. • Yes. Mainly for the understanding of engineering. I will use parts of the plant unit since I teach Fast Grow during the year. • The workshop used materials and projects that will be useful in teaching engineering concepts. • As a result of this workshop I will enter my classroom next September more confident in fostering the problem solving process that engineers use in our society. I feel more comfortable facilitating a classroom that is driven by student queries and solutions. • It made me really think about what I will do better next year with the units I teach especially in making connections from the story to the design challenge. It also made me realize how important the discussion after is as far as talking to the students about what worked best and why. • I have always been comfortable teaching the cute fuzzy science topics, like butterfly life cycles. I now feel like I have much more confidence to teach the engineering/technology topics. Even though I need to know more, I feel like this workshop set me on the right path. • In engineering, there isn't always one correct answer and it's okay to fail and try again. This is a somewhat different message than kids generally get in school. With this in mind, I will change the way I teach.	• I especially appreciated the speaker on "women as engineers". I can better visualize and talk to students about the possibility of this kind of future for them. I am reminded of the constructivist approach and noticed the value of the chance for "redesign" on some of these projects. As you know, time is always the issue. • Yes, by implementing the design process I will be asking kids to think more for themselves, create with fewer restrictions the way they believe is best and I believe this will generate a greater interest in the science curriculum. • I will use the engineering design process not only when teaching engineering or other science disciplines as well as adapting it to other curriculum areas. • I will be sure to incorporate the design process into my classroom across the curriculum. • My whole science focus and time is going to change this year so I am very excited to be able to use the model of the design process in my classes this year. I like the idea of the group work, discussion and execution of the challenges that PCET has presented. • Yes. One of the speakers recounted her experience as an elementary school student. After hearing her express her view that she did not get enough science as a child, I was moved. It made a profound impact on me. • I currently use the inquiry method and realize the value of experience-based learning. I will emphasize the engineering process more and discuss its relationship to the writing process. Revision is an opportunity to improve. I also plan to make more connections for my students with the real world.

Participants were asked for additional comments at the conclusion of the survey. These comments were again hugely positive, with the suggestions for improvement almost invariably referring to ways in which the scheduling might be improved.

Table 8: Concluding Open-Ended Comments

Positive	Suggestions
• Thank you for the opportunity to learn the engineering design process and bring it back to my students! • It was a GREAT week! I felt, and still feel, a little overwhelmed by all of it. I appreciate how smart and organized engineers have to be, but as always, I love the teamwork aspect. • This was THE BEST workshop I have ever attended and that includes all the workshops I attended while in the Biotech industry. Bravo to you all! P.S. Do you have a similar type workshop addressing the science frameworks? • This was one of the most useful and helpful workshops I have attended in the area of science. I feel very lucky to have been accepted to attend. • I think the whole idea of EiE is fabulous because most elementary school teachers do not come out of college with any background in engineering, yet this is a part of our state frameworks which we are expected to teach. Having attended the PCET workshop has helped me to feel more comfortable addressing this part of the frameworks in my classroom. It has definitely added to my knowledge base and I have also discovered some good resources that I can look to when engineering/technology questions come up in my classroom! • This was one of only a few workshops that I have felt excited and confident about implementing the curriculum in my classroom. Everything was well thought out and planned. I cannot wait to teach the Bridging unit.	• I think that time could have been used more efficiently throughout the workshop. The teaching that was modeled was not always effective and, more often than not, the teachers did not seem well prepared for their lessons. • I enjoyed the week especially working the 'mentors'. Although I know that the time constraints did not allow us to do hands-on with all of the units I felt the ones that we did not do were glossed over much too quickly. I don't know how that could be remedied and if it is fully necessary but I thought I would point that out to the staff. • Overall the workshop was a valuable experience. However, planning needs some improvement. For example, we only had one fan to test windmills for the 30+ workshop participants. Some materials could have been copied to transparencies so that all of the participants could view them properly. I believe the schedule could have been tightened. • I think each table should have each unit presented whenever we are working. Last year was two weeks for the program. I would have liked to have done all the units (I realize that would be impossible) • I really enjoyed the workshop, but wish that there were units directed more towards first grade material. • The workshop day was too long. By the middle of the week most were too tired. I would have liked to have this done in a long morning session.

Focus Group Findings

At the conclusion of the Tufts workshop, three focus groups were conducted, two by Russell Faux and one by a Museum of Science researcher. The key domains for these focus groups were:

1. Changes in participants' awareness of, and perspectives on, science, technology, and engineering
2. Changes in participants' perspectives on the capabilities of students to carry out engineering activities for important learning gains
3. Perspectives on the implementation of the EiE units in elementary classrooms

Each group comprised 6-8 participants, was recorded with transcriptions made of the recordings. These transcriptions were then analyzed using HyperResearch.

The focus groups tended strongly to corroborate what was found in the survey data above. Participants gained in their awareness of, and appreciation for, engineering. Participants said they thought they EiE materials would work well as a means of conveying engineering thought to students. The learning activities that the participants envisioned for their students would be both engaging and highly generative. The use of these engineering activities was an excellent fit for the elementary classroom, with the strong prevalence of differentiated instruction, the need to encourage students to work together in a hands-on and real-world setting, to reflect collectively, to take risks, and, perhaps most importantly, view failure as an opportunity to learn and improve.

These analyses are summarized in the following table:

Table 9: Focus Group Findings Synthesized

Domain	Finding	Examples
Participant Awareness	Confirming the survey findings, participants reported heightened awareness of the ubiquity and accessibility of engineering thought	• I feel like I have a much better understanding of what engineering is, I feel like I have a much better understanding of what technology is. • I found that I feel I really understand what engineering is now, which I didn't before. • So when you see it from the standpoint of all the different facets of engineering, it really opens the whole world of possibilities to kids.
Expectations for Student Learning	Participants consistently declared that students would benefit from engaging in the EiE	• I've come out of this thinking that this is wonderful for the children, to give them that other component, that creative "use what you know." • I saw presenters for 1st grade that I was sure that those children would not be able to do the things that they were doing with them and, yet, they did them. So I think I've changed in my expectations of my students. I believe that I would think they would be able to do more. • I think the improvement part of the engineering process is probably the most important thing because you just don't say, "Oh, that's it, that's good enough, I'm done." They're always improving. So I think that's really important for kids when they want to say - when they think there's only one right answer, when they get the right answer, that's it, they shouldn't have to think anymore. And that's what I think is one of the most valuable things.
Prospects for Implementation	While some logistical and scheduling problems may persist, participants were confident that the implementations would go forward and be successful.	• I would love to show this to my principal and be like "Well, this is what a real classroom looks like." • Initially if you told me that I would have to have my class make windmills or bridges I would have said, "Are you out of your mind? It's way too over their heads." But they broke it down in such a way that it's feasible. • Everyone should see that wind demonstration. I feel like the whole state of Massachusetts should see that.

Conclusions & Recommendations

It is rather rare in education program evaluation to view such a large and far-flung undertaking be so consistently and strikingly successful as the 2007 PCET summer workshops. The data are clear in underscoring the truly stunning degree to which PCET met its core objectives. Participants spoke effusively and often of the tremendous gains they had made, the revelatory quality of their newfound appreciation for engineering, and the clarity of their understanding on how to introduce EiE materials in their classrooms.

In view of the foregoing, DSRA hesitates to offer recommendations, however, it may be the Project would wish to consider the following:

- Pre-post testing of participants at the summer workshops, rather than relying on self-report data
- As implementations evolve and mature, collect enough student learning data to begin to develop a regression model of effectiveness across different venues
- Move to build something along the lines of FaceBook to support the social networking possibilities coming out the workshops.