The Boston Museum of Science BEST Project

Interim Report

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Executive Summary

The following report presents the findings from the evaluation research conducted by Davis Square Research Associates (DSRA) on the Boston Museum of Science Bridging Engineering, Science and Technology (BEST) project, funded by the National Science Foundation, and designed to strengthen the teaching and learning of engineering content in elementary school teacher preparation programs. The current report summarizes the findings from a focus group of community college faculty participants in the BEST project. The purpose of the focus group interview was to gather information on the experiences of the faculty as they introduce preservice teachers to the uses and values of the Engineering is Elementary (EiE) content and resources.

Key findings include:

- Participants reported that the EiE materials were easy to prepare and implement as well as readily fit into the curriculum
- Participants reported that the preservice teachers responded very positively to the engineering content in their teacher preparation classes
- The preservice teachers were said to have reported having had very positive experiences in the implementation of engineering in their field placements
- The prospects for a greater dissemination appear to depend on a person-to-person rather than a systematic effort.

Sample & Method

The sample for the report is composed of five faculty members from a Boston area community college, all of who prepare preservice teachers for careers, generally in early childhood education.

The focus group met at the community college in March 2011, with Russell Faux of DSRA facilitating the discussion. The interview was recorded and transcribed by Word-by-Word (San Francisco, CA) for later analysis in NVivo by DSRA. The protocol for the interview is built on the very extensive work on the current and antecedent projects, with the domains of significance being (1) preparation for the lesson, (3) implementation and its effects, and (3) prospects for dissemination. The interview lasted about one hour, with all participants very active in sharing and

exchanging their experiences, insights, and reflections on the BEST project.

Once the interview had been transcribed and received by DSRA, the transcript was loaded into NVivo for the following analysis. While the use of qualitative data analysis software is invaluable for the management and malleability of the coded data, the actual coding of the transcript needs to be done painstakingly and line-by-line. The assignation of a code or codes by the analyst to a given line of the transcript entails a great deal of judgment on the part of the researcher, and thus there is every reason to conclude that what follows represents a rather subjective take on what the teachers' said. It is likely that another researcher, with a different set of perspectives on the data, would arrive at a distinct set of findings. However, we hold that what follows is a reasonable set of ascertainments, ones with an adequate empirical warrant, and that will resonate among readers familiar with the current or similar projects.

As stated above, the codes for the current report are extensions of previous work done with EiE-related efforts. These codes follow what we hold to be a natural progression from preparing lesson, through its implementation, assessment, and eventual replication. The codes for the analysis of the focus group are

1. *Preparation*: This code refers to instances of the participants' talk around the work directly related to the conduct of the lesson that needed to be completed prior to the eventual teaching of the lesson.
2. *Implementation*: This code refers to events that took place in the class during the conduct of the engineering lesson. The use of the code in the current report is herein used in a rather narrower sense with respect to the uses of the term in other contexts.
3. *Cross-Disciplinary Connections*: This codes refers to the general "fit" of the engineering content within the overall curricular space managed by the teacher
4. *Student Response*: This refers to the students' attitudinal and behavioral responses to the engineering unit
5. *Student Learning*: This refers to what the focus group participants reported as their students having learned in the engineering unit
6. *Teacher Learning*: This refers to what the focus group participants reported as having themselves learned through their participation in the project.
7. *Dissemination*: This final code refers to what the participants reported as the prospects for a wider adoption of the EiE content.

The key questions for the focus group were:

- What are the key themes in the experiences of the faculty in terms of implementing the EiE content?
- What has been the student response to the engineering content?
- What are the prospects for dissemination of the EiE content?

Interview Findings

In this section DSRA presents the findings from the focus group, with the presentation organized by code, following a sequence that is more or less reflective of the process of preparing and conducting a lesson.

Preparation

The focus group teachers found that the EiE lessons were not difficult to prepare. The participants cited two reasons for this ease of preparation. The first is the increased teacher competency acquired through previous experience, while the second reason to be cited was the quality of the EiE materials. The respondents who reported doing EiE units for the second time declared that not only were their ideas about the lesson more clear, but also their capacity to manage student learning were improved. The talk about the materials mentioned no gaps that caused any problems in preparation, and the EiE lessons were described as being structured in a way that allowed for ready implementation.

An example of the value of previous experience: *Yeah, but this semester it's a piece of cake because it's – I've done it once and I know exactly what I want to have them do. It's clearer to me so I think it'll be a lot clearer to them.*

The participants also noted the thoughtful design of the EiE materials themselves: *The structure was there and there were samples of – There was a sample for the evaluation of the birdfeeder to see – I used the same evaluation setup that you had except for the section about the cost. There wasn't any cost involved; I gave them dowels.*

Note that in this quote the faculty member recalls a successful effort at modeling the lesson assessment: *When we were doing the first lesson then I went over the rubric that teachers would use, so I showed them how to rubric it. Then we did the second lesson and then I had them rubric the lesson themselves too. I wanted to show them how they would do a rubric if they were in a class so I brought that whole skill in too.*

Even one participant who had not implemented anticipated little in the way of problems: *I haven't done it yet either. My class is this term's class so – The unit I have is on the cell membrane so we'll get to that right after vacation. We did do a thing where we used the five steps though of the engineering process that came with the EIE to make birdfeeders.*

Implementation

The faculty characterized the implementation of the lessons as having gone exceptionally smoothly. The addition or subtraction of materials was readily accomplished, and the structure of the EiE lessons was seen as remarkably user-friendly.

Examples of simple distributions: *I gave them all kits. I put them in groups of five and they do it in group work. I gave them all a packet, a brown bag, and it has like the tuning fork in it, the tubes, the elastic, everything else. And I said, "This is what you have to have.*

The fit into the curriculum was not seen as especially labored or contrived: *Our students let them know in advance that they have to do three activities, either math, science, language, whatever. And if they're doing a theme then they give them the theme and the students take it from there.*

Once the lesson has been launched, the students could co-regulate in productive ways: *I feel like an orchestra leader. When you get them in a group and you give them the assignment and you're just kind of pulling things together, helping them to pull things together and taking it a step further. In fact, I don't – sometimes I feel like I'm not really teaching because they're doing it. They're doing the work.*

There are some unknowns, however, as the engineering content is used a varying levels. The "paras" in the following quote refer to para-professionals who assist the teacher in managing the classroom: *This semester I'm interested to see what I'm going to come out with because I've got some that are in older groups. I've got one in fourth grade; I've got one in eighth grade. I mean this is the biggest group of paras I've ever had, half my class is paras. So I'm really interested to see how they're going to work it into their lessons and stuff. I mean the teachers are very committed to it and they say, "Yeah, there's no problem with it," but it should be interesting to see how they bring it down because I've got preschool kids, I've got kindergarten up to eighth grade. So it's really going to be interesting how they tweak it to those particular age groups this year, this semester.*

One faculty member wished to express how easy it was to extend the lesson by bringing in other materials: *I added the 60 Minutes video on elephant and they had the spectrograph and they interviewed a woman who was in Africa analyzing elephant sounds. So it was easy to add things.*

Cross-Disciplinary Connections

The focus group faculty expressed some tendency to shape the EiE content into something that would fit well into the pre-existing science curriculum. While attention was clearly being paid to using the engineering content in a literacy-related lesson, in general the focus group members saw the fit between engineering and science as a natural one. There are at least two reasons for this. One has to do with the more science-related backgrounds of some of the focus group participants, and the other has to do with the conflating of the engineering design process with the

scientific method. Even the faculty involved in literacy tended to describe engineering as conceptually close to science.

One faculty member wove the engineering into a pre-existing lesson, discarding a part of the EiE materials: *I was teaching the science course so I tried to wrap it into some science a little bit, the science of botany. So I didn't use the scenario in the module, which was about a young girl who gets a plant from Hawaii and tries to pollinate it. I turned it into colony collapse, teach them a little environment stuff, there will be colony collapse. So I had to do a little bit of work for that but that was just going out on the Web and finding something useful so –*

Other project participants with a strong science commitment appear to have influenced this group to some extent: *At the summer reading . . . one of the schools was saying how they tried – when they do it in their science classes they try to ramp it up a little bit and make it more science-y. So it worked.*

One faculty member spoke of EiE as though it were science: *I had one of my student teachers request more science materials in her center because they didn't have enough science stuff. So she used the EIE unit and loved it and asked her director if they could buy more science stuff.*

One faculty member alluded to having to find a legitimized place within the current policy environment, which does not explicitly support engineering: *We have to follow the preschool standards and they use the standards under math, science and technology. But they also use the standards under language and literacy and I try to help them find a common ground between math, science and technology and language and literacy. But they can use the same project for both practically.*

Another faculty member saw the engineering focus as something that could be readily accessed from various curricular vantage points: *I had my students doing a language and literacy unit and from that unit they're going to make a math project and a science project. I think they're able to see it clearer because I am and implementing it they can see, "Okay, this is language and literacy. What do you see in your language and literacy unit? You see numbers, you see letters, you see colors, comparisons and all of that." I don't think I would have done that without this experience.*

This last point was supported by another colleague: *I think the biggest thing for* [the preservice teachers in the college class] *is that they realize how many things are related to each other and I think nothing is separated for them. In the past I've separated everything and this time it was if you do a science activity how can you incorporate it into a storybook or an art activity or – So they're able to do several things with one unit.*

<u>Student Response</u>

The students in the classes of the focus group students were overwhelmingly preservice teachers intending to work in early childhood or family childcare settings. The responses of the students can be parsed into the immediate reactions in the

college classrooms, and then again into the reported experiences of the students as they implemented EiE content in their student teaching practicum placements.

One focus group participant spoke of the liveliness of the lesson as conducted at the college: *It was tied into a unit on botany and flower structure and they loved it, they really – a lot of conversation, it was very noisy in the room, which was very good. And when you asked them they felt it was a very positive experience. Some of the students said, "Oh, yeah, I've been doing stuff like this," meaning, you know, pollinate, not the engineering part. And also I saw some improvement on – not your pre- and post- but the ones – with the results with the ones that I gave and that there was – it seemed to be a better understanding of engineering principles. They were people who really had no clue before.*

The iterative processes demanded by the EiE units were cited as being of importance for the college students: *My students did a waterwheel and it was really interesting to watch them because they thought they were getting behind everybody else because theirs didn't work right away. I think they learned more by it not working right away because they had to go back to the drawing board and try to figure out, "Okay, what do we do now?"*

The classroom atmosphere was described as very lively: *We did the science doing the module. We did the activity where you build a tower out of cards and you have to put a little stuffed animal on top. They went wild with that.*

The competition. They were looking at each other and spying. Just the different – there was different designs. There must have been six tables, six different designs. The same thing we did with spaghetti. They were so competitive.

There was some anxiety among the preservice teachers on how well the EiE would work in their school placements, but the initial results were reported as being very positive*: My students were like, "How are we going to bring this into our classrooms?" and "This is going to be difficult." And they came back and they said it was marvelous. They absolutely loved it.*

The supervising practitioners were said to have been very supportive of the engineering lessons conducted by the preservice teachers: *My students, where they're doing their pre-practicum, their teacher, supervising teacher, wants them to bring the stuff in and do it with the kids, which is wonderful.*

Okay. I guess that's the point I was looking to establish here, that when the students, pre-service teachers take it from here and take it out into the world it's well received.

<u>Student Learning</u>

When the focus group turned to what engineering concepts the students learned through doing the engineering unit, the faculty members spoke in rather general terms, citing

- Importance of experimenting
- The design process
- The characteristics of materials
- Failure
- Fun
- Group work (including listening & communicating)
- Competition
- Creativity
- Respecting one another
- Evaluation
- The value of hands-on learning.

Overall, these were seen as the hallmarks of "good teaching and learning," rather than as notions unique to engineering. This point may be similar to the point above that the engineering process can be construed in a variety of ways in order to be readily accessible from various curricular vantage points.

Another point of some importance is the link between the engineering design process and the scientific method. These two were described as "different names for the same things." The eventual importance for this convergence is not clear, though it is clear here that linking the design process with the scientific method further supports the ease with which the engineering may be incorporated into contexts in which engineering would not be likely to appear.

Teacher Learning

Another domain touched on during the focus group interview was that of teacher learning. The prospect of "doing engineering" is frequently a new one for BEST participants, and one that has often created some discomfort among participants without extensive backgrounds in STEM. Thus one of the many challenges for BEST is to foster improvement in the participants' sense of self-efficacy around using engineering content in the courses.

As one faculty member expressed it, there was little predisposition to embark on the incorporation of EiE: *I didn't like doing math or science, quite frankly, because I didn't think I knew how to do it. And implementing it has shown me how much involved science, math and technology are involved in just about everything.*

Upon reflection, one faculty member realized that much of what was being done in the course was analogous to engineering: *I think it was doing some of it and didn't realize I was doing it.*

The fit between the EiE materials and typical instructional strategies was seen as good: *Nobody sitting here is probably at the straight chalk-and-talk or whiteboard talk anymore so – It just becomes another tool for the kit.*

The incorporation of EiE engendered some reflection on the sources of the some of the faculty's own discomfort with STEM: *Well, it was a great experience for me*

having flunked geometry in high school and then being a part of this and realizing that I could have done it. I could have done it in high school had I had the basics.

Given the faculty's capacity to overcome this aversion (that is, those without STEM backgrounds), the notion that the student teachers should be able to do the same becomes stronger: *And what we're doing here I think in early childhood is that we're hopefully taking away that fear and to enjoy it.*

Dissemination

While the five focus group respondents were unanimous in their enthusiasm for the use of engineering in their classes, the prospects for a greater dissemination were less certain. On the one hand there was a generally-expressed confidence in the grass-roots, or person to person transferral of information through informal networks.

The following is an example of informal advocacy: *I was at a Northeast Regional meeting and people were asking what were we doing with math and science and technology. So I was telling everything we were doing.*

In terms of a greater dissemination within the community college, the faculty thought that the enthusiasm for engineering would spread in an almost viral manner, without the formal intervention of leadership: *I think sometimes the faculty are looking at that we're having a good time and that we see the benefits from it.*

An important obstacle for the greater dissemination of the engineering innovation is linked to the large number of adjunct faculty working at the college. The faculty network is not as dense as would be propitious for the spread of the innovation. Many adjunct faculty hold other positions at other schools during the day, and they come to the college to teach in the late afternoons and evenings. The professional development of this group is problematic, given the "thin" qualities of the teacher network.

One faculty member's response was: *I try to entice them into look at the projects that these kids did. I mean they're just outstanding. They did the project and they get a good grade and then they get to demonstrate it with a whole bunch of people statewide looking at their work.*

Yet the enticements of observing compelling student work can be offset by other considerations: *I mean the hard part too is that some of the teachers that are in our department teach in the public schools so they can only make stuff at night.*

In short the greater dissemination of the EiE innovation will be dependent on individuals presenting the case to other, potentially receptive faculty members. Depending on "peer contagion" for the diffusion of an innovation may or may not be a successful strategy at the community college in question, and thus DSRA concludes that the prospects for dissemination remain clouded.

Conclusions & Recommendations

The five faculty members participating in the focus group were united in their appreciation for the EiE content and materials. Even those with weak backgrounds in STEM were able to overcome their anxieties and acquire the confidence needed to implement these innovative materials. The curricular fit was not seen as difficult, and the responses of the preservice teachers were very positive. Likewise, the preservice teachers were described as successful at implementing engineering units in their field placements, and these implementations enjoyed the support of the cooperating practitioners.

Given the above, DSRA finds it reasonable to infer that these faculty members are likely to continue to implement the EiE lessons. However, the further dissemination of engineering within the college was described as hindered by the fleeting availability of the many adjunct faculty. The peripatetic adjuncts were characterized as having to reconcile competing priorities, with little "space" remaining to devote to the challenges of a professional development program that takes participants out of what they considered their comfort zone.

Given the above, DSRA recommends the following:

- That the project consider exploring further the relations between science and engineering. The participants were clearly ready to use the two almost interchangeably and this may or may not be indicative of some conceptual misunderstandings.
- That the project consider ways of conducting on-site workshops. This would not entirely address the adjunct faculty issues, but it may help in bringing the content more directly to faculty who would not otherwise participate, had they to go to the Museum.