



Museum of Science: Engineering is Elementary
Impact on Teachers With and Without Training

Rosa Carson, BA and Patricia B. Campbell, PhD

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The Engineering is Elementary (EiE) project at the Museum of Science (MoS) in Boston, MA is a research-based engineering curriculum for elementary age children. EiE integrates engineering and technology concepts with elementary science topics. The goals of EiE include increasing student technological comfort and skills as well as knowledge of various fields of engineering. EiE also aims to help elementary educators enhance their engineering knowledge and pedagogy through professional development workshops. It is expected, however, that teachers will be able to implement EiE without professional development workshops.

To begin to look at the impact of EiE training on teachers, EiE teachers were asked to volunteer to be part of a study where they identified a non-EiE teacher in their school who was teaching at the same grade level. To the degree possible, an attempt was made to match the amount of teaching experience. Four teacher teams participated in this aspect of the evaluation. The teacher pairs completed both pre and post surveys and reviewed the three 2006-07 EiE units. As part of their EiE commitment, EiE teachers agreed to implement at least one of the three 2006/07 EiE units in their classrooms with materials provided by the MoS. The matched teachers were invited to implement any units they liked, but they did not receive materials.

The following is an overview of the results from the four teacher teams. Two teacher teams were from California and two were from Minnesota.

Theresa/Joan¹

EiE trained teacher *Theresa* and her match *Joan* are teachers in their mid 30s with 6-10 years of teaching experience. Both teach fifth grade and have advanced degrees in elementary education. Neither had been involved with EiE prior to the 2006-07.

80 Lakeside Dr., Groton, MA 01450 978 448 5402 www.campbell-kibler.com.

¹ The names of all teachers have been changed. The names of teachers receiving EiE training this year are in italics.

Teacher Engineering Attitudes and Activities

Prior to her involvement with EiE, *Theresa* identified one engineering activity she did in her classroom: building tracks for ball bearings with a goal of making the ball bearing jump a gap or go a certain distance. Joan's use of engineering in the classroom prior to participation was limited, as well. "We do science and math, but I don't know if anything is considered engineering."

Like all but two of the teachers who participated in the evaluation study, both *Theresa* and Joan focused on computers when asked about technology-related activities in their classrooms. According to *Theresa*, "[w]e use computers, but primarily for Word documents." Similarly, Joan's comment on this topic was, "[s]tudents use word processing and make PowerPoints."

Before her EiE training, *Theresa* indicated that she would like to include more engineering content in her classroom if she knew more about it herself. "I think my students would enjoy it," she noted on the pre-survey. Though Joan was not to receive any training, her attitude was similar. She indicated that she would like to include more engineering content in her classroom on the belief that "it would benefit my students and increase their interest in science and math."

After their implementation of one EiE unit and review of the two others, and, in *Theresa's* case, EiE training, both teachers completed a post survey covering the same material and attitudes as the survey they took at the beginning of the year. In this post-survey, both defined engineering as the use of technology in problem-solving.

Joan indicated that the only engineering activity she had done in her classroom was the EiE unit. For her part, *Theresa* continued her use of marble tracks, and also mentioned that her students were "working on pendulums [and] flippers." Both teachers continued to focus on computers as the way that they used technology in their classrooms.

At the end of the year, both teachers continued their interest in integrating more engineering content into their classes. Joan wrote, "[a]s I have started to learn what engineering is, I realize that it has MANY practical applications and can draw students of all abilities and interests. I [didn't] realize how far reaching engineering applications really are."

Engineering is Elementary Unit Review and Implementation

As part of her participation in the MoS pilot project, *Theresa* anticipated teaching only bioengineering in her classroom. Upon agreeing to participate as a match, Joan was unsure which, if any, units she would teach. Ultimately, both taught bioengineering in their classes and did not teach either of the other units. Because they teach in the same school, Joan was able to reuse many of the materials that *Theresa* had received from the MoS to implement the activities with her class.

The reason *Theresa* gave for not implementing the other two units was a lack of materials and classroom books. Joan, however, focused on time limitations as the reason she only used bioengineering.

Bioengineering

Both teachers read *Juan Daniel's Fútbol Frog* with their classes and found the level of the reading and science content to be appropriate for their students. They differed in the degree to which they saw the unit tying into other science activities, with *Theresa* finding a moderate connection and Joan feeling there was a strong tie-in.

Both would recommend the unit to other teachers, with particular attention to the prep lesson in combination with the materials list. According to *Theresa*, “[t]he prep lesson was great! It really opened my and the students’ experience to what it means to be an engineer and use tech. The hands on lessons were great. The accurate supply list was helpful.” There were no sections of the unit that either teacher indicated was not useful.

When focusing on weaknesses of the unit, *Theresa* indicated that “the charts were not very useful.” Joan did not mention the charts, but did find the teacher guide “a little too wordy.” Neither teacher used the literacy connections fully, but Joan indicated her hope that she would use them in the future, and *Theresa* used them as an activity to engage fast finishers while other students continued working.

Electrical Engineering

Neither teacher implemented *A Reminder for Emily*, but both reviewed it and found both the reading and science levels to be a good match for their students. While Joan saw a high potential for tie-ins with other science activities, *Theresa* indicated a low possibility for such tie-ins with this unit.

Theresa indicated that she would recommend the unit to others, while Joan was unsure, because she had not taught the unit in her classroom. Both rated most of the sections of the unit highly useful. However, *Theresa* found the unit assessment moderately useful and the materials list only slightly so, while Joan indicated that both the unit summary and unit assessment were moderately useful.

The strength of the unit, according to *Theresa*, was in the introductory lesson, both for its engineering content and its helpfulness to teachers in planning the timing. Strengths that Joan called out were the vocabulary and literacy connections. *Theresa's* thoughts about unit weaknesses were that the assessments were strangely organized, and that a list of places to get some of the materials necessary would be useful. With regard to weaknesses, Joan pointed out that some areas were too wordy.

Acoustical Engineering

Neither teacher implemented *Kwame's Sound*, but both reviewed it and found both the reading and science levels to be a good match for their students. Additionally, both saw ready tie-ins with other science activities.

Theresa indicated that she would recommend the unit to others; *Joan* was unsure whether she would, based on not having completed it at the time she was reviewing it. Both rated the unit summary charts and unit assessments as being of low or medium usefulness, but found the rest of the sections of the overview and lessons to be highly useful. Strengths of the unit, according to *Theresa*, included the background on engineering, vocabulary, and possible pitfalls of the engineering design process. The strengths *Joan* noted were the good sequence and thorough information, saying that “[i]t’s easy to understand and follow, especially for someone who has no previous knowledge.” As with the bioengineering unit, *Theresa* found the summary charts confusing.

Judith/Maria

EiE trained teacher *Judith* is a middle-aged teacher who declined to specify the number of years that she has been teaching. Her match, *Maria*, is a young teacher with three years of teaching experience. Both teach fourth and fifth grade and both have advanced degrees. This is the first year of involvement in EiE for both teachers.

Teacher Engineering Attitudes and Activities

Judith's definition of engineering before training was, “[e]ngineering applies science, math, and technology to problems to help design solutions.” Before her participation in EiE, she said that “most activities we do relate to understanding the scientific concepts.” *Maria's* definition of engineering was that it is “planning or designing a product or invention and then building or creating it.” Thus, she identified “building missions” as a classroom activity involving engineering that she already implements. Like *Theresa* and *Joan*, *Judith* and *Maria* both identified their in-classroom technology use exclusively in terms of computers.

Before engaging in any EiE activities, both teachers indicated that they would like to include more engineering content in their classes. To explain why, *Judith* said, “I think teaching science topics and applying the topics to making something would provide a more holistic way of teaching. Solving a problem with science will teach the students how to apply science to their lives and how it is already used in their lives.” *Maria's* reason focused on the more immediate term of student learning: “I think that students learning how to think, plan, and create new inventions is great.”

At the end of the year, *Judith's* definition of engineering had expanded to, “[t]he use of math and science to design, create, and manufacture products. The products can make people’s lives easier, help in research, transportation, excavation, and so much more. Everything we use in our lives has probably been engineered. The products could be

modeled after nature or [on] completely novel concepts.” In comparison, Maria’s definition of engineering was somewhat spare: “[d]esigning or creating things to make everyday life easier.”

In reference to engineering and technology activities done in their classrooms, *Judith* identified the three EiE units as the engineering content she used, while Maria reported that she did no engineering activities with her students during the year. Both continued to report computer-related activities as the technology activities done in their classrooms.

While both teachers expressed an interest in including more engineering in their classes in the future, *Judith* had a focus on opening her students’ eyes to new fields – “I like the thinking process needed to solve many engineering problems. I would like students to know what areas are out there to work in, study, and learn more about.” Maria’s response was more general: “I think the engineering steps are great and can be applied in many aspects of life.” *Judith* noted, “I am not sure when and if I will get a chance to teach [EiE] these units again. I would consider incorporating them into other work that I am doing.”

Engineering is Elementary Unit Implementation and Review

As part of her participation in the MoS pilot project, *Judith* implemented all three units in her classroom over the course of the school year. As a match teacher, Maria implemented none of the units with her students.

Judith’s comments about teaching the three units were that she did it by the book as much as possible since it was her first time using them. Maria was hopeful that she would be able to use the units in future classes. Of all the units, *Judith* noted, “I would recommend the entire unit but let other teachers know that they can opt out of some of the lessons if they don’t have enough time to do everything.”

Bioengineering

Judith had her students read *Juan Daniel’s Fútbol Frog* independently. She rated the text as being highly appropriate for her students’ level both in terms of reading and in terms of science content. In contrast, Maria indicated that the book was highly appropriate for her students in terms of reading, but only moderately so in terms of science content. While *Judith* felt that the book’s tie-in potential to other science activities was unknown, Maria saw it as being appropriate for that, as well.

Judith was not sure if she would recommend the unit to other teachers. She found her students didn’t connect to the story. She thought that in the future, she might use a tie-in lesson on Central America to help her students connect to the story. But Maria felt she would recommend the book to other teachers, with a particular endorsement for teachers of classes with a significant Hispanic population.

Among the strengths they called out in this unit, *Judith* mentioned that the guide was very helpful, and especially that she “like[d] the experiments because they [were] a step by step guide that helps you understand what an engineer might do to design a solution.” Maria was especially fond of lesson two.

Maria’s focus when identifying weaknesses of the unit was on the limitations of the prep lessons. She noted that when a teacher implements more than one unit in her classroom, the prep lesson is only useful once. *Judith* suggested that pictures of the materials in question would be a good addition to the materials list, as well as alternative materials in case those listed can’t be located.

Electrical Engineering

As she did with the bioengineering unit, *Judith* had her students read *A Reminder for Emily* independently. Maria commented that she would like to use this unit in the future when she’s teaching 4th or 5th graders. Both teachers identified the reading and science levels as being highly appropriate for their students. In a reverse of their previous positions on the bioengineering unit, *Judith* saw the science tie-ins as being highly relevant, while Maria found them only moderately so.

Maria would recommend the unit to other teachers and appreciated the tie-in to pet care. *Judith* was unsure as to whether she would recommend it because her students didn’t connect to the story.

Judith found the examples to encourage students to think about the topics in the book and experiments being done as one of the strengths of the unit. Additionally, she liked the gradual build-up of knowledge from each lesson to the next. *Judith* pointed out that the holiday lights were difficult to work with and that that it would be better if they were replaced with real lights, as found in other electricity kits.

Acoustical Engineering

As she did with the prior two units, *Judith* had her students read *Kwame’s Sound* independently before doing the engineering activities in the classroom. Maria noted that she anticipates using this unit in her classroom next year. Both teachers indicated that the reading and science levels are appropriate for their classrooms, but while Maria saw tie-ins to other science activities, *Judith* felt this unit was weak in that area.

Judith found students were not enthusiastic about this book. “If I were to do this again, I might bring in some drums and have them blindfolded to connect with Kwame and what he had to do to communicate with his cousin.” For this reason, she was unsure as to whether she would recommend it to other teachers. Maria, in contrast, would recommend it for its cultural diversity and for teaching her students about people with disabilities.

Maryann/Joyce

EiE teacher *Maryann* and her match *Joyce* are both middle-aged teachers, each with more than 10 years teaching experience. Both are teaching K-6 science and special education resource teachers. *Maryann* has an undergraduate degree in elementary and special education, and *Joyce* has an advanced degree in elementary education. *Maryann* was involved with EiE last year as well as this, while this is *Joyce*'s first year with any EiE participation.

Teacher Engineering Attitudes and Activities

At the beginning of the year, after previous EiE training but before receiving training on the 2006/07 units, *Maryann* defined engineering (actually, engineers) as, “[t]he designers of things to be built.” *Joyce*'s definition was, “[d]esign, building, and use of engines, machines and structures.” The engineering activities that *Maryann* was already doing in her classroom included “models and designs, electricity and magnets, balance.” Those *Joyce* was already doing included “sounds, models and designs, ideas and inventions.”

Maryann and *Joyce* were the only teacher pair to start the year with definitions of technology-related activities in their classroom that include a broader scope than computers. In her classroom, *Maryann* indicated that technology-related activities already in practice are “tinker toys, legos, electric circuits, blocks, etc.” *Joyce*'s class' technology exposure included proscopes as well as science fair writing and questioning.

Initially, both *Maryann* and *Joyce* wanted to include more engineering content in their classes in the future. *Maryann* expanded on this by writing, “I want all inner-city students, especially girls, to consider engineering as a possible course of study.”

End of year engineering attitudes

At the end of the year, *Maryann*'s definition of engineering was, “[e]ngineering is the creative use of scientific principles.” *Joyce*'s definition was, “[a] part of science and technology dealing with building, design, use of machines, engines, and structures.” Despite her indication of broad use of engineering in her classroom at the beginning of the year, at the end of the year, *Maryann* reported doing no engineering with her students. In comparison, *Joyce* indicated that she was still doing engineering with her students, including units on balance and motion; levers and pulleys; and sink and float.

Although both teachers similarly began the year with a broad definition of technology-related activities in their classrooms, in the post-survey, *Maryann* indicated that she did no technology-related activities with her students, while *Joyce* identified only computer-related activities and the fact that the state test is online this year.

Despite these changes in what might be perceived as a backwards direction, both *Maryann* and *Joyce* would like to include more engineering content in their classes in the future.

Engineering is Elementary Unit Implementation and Review

As an EiE trained teacher, *Maryann* implemented one of the EiE units – electrical engineering – in her classroom. However, *Joyce*, her match teacher, implemented all three units with her students, tying all three into already-planned science lessons over the course of the school year. Both found the engaging stories to be a strength of all the units they reviewed.

Bioengineering

Maryann did not read *Juan Daniel's Fútbol Frog* with her class, though she indicated she might use it sometime in the future because students would likely be interested and motivated to try the experiment. *Joyce* read the story with her class and tied the unit into an already planned unit on structures of life in her curriculum. Both teachers found the reading level to be a good match for their students' abilities, and *Joyce* indicated the same about the science level of the unit, while *Maryann* found the science level to be moderately well-matched. Similarly, *Maryann* saw a moderate opportunity for tie-ins with other science activities, while *Joyce* indicated a strong possibility for it.

Both teachers would recommend the storybook to other teachers, having enjoyed the story and found it fun and engaging. *Joyce* would recommend the entire unit to other teachers, while *Maryann* could only recommend the storybook, as it was the only part she read. *Joyce* made particular mention of the demo cards and handouts being a strength. She found the big vocabulary words a potential weakness of the unit in use with third graders, although her class was able to understand them.

Electrical Engineering

Both teachers read *A Reminder for Emily* with their classes. *Maryann* indicated that her students loved the story and were eager for each new chapter. *Joyce* fit the story into an electricity unit she already planned to teach. *Joyce* found the reading and science level to be a good fit for her students' abilities, and *Maryann* indicated that the reading was a good fit for her students, while the science was a moderately good fit for their skills. Both teachers saw opportunities for tie-ins with other science activities.

Both teachers would recommend not only the storybook to others, but, in fact, the entire unit. The strengths of the unit were that it was well laid out and easy to understand. *Maryann* found was that it was more information than she expected and that while she "assumed it was difficult, but it wasn't."

Acoustical Engineering

Maryann did not use *Kwame's Sound* with her students, but Joyce read it with her class. Both teachers indicated that it complemented a unit on sound that they already teach. As with the other units, Joyce found the level of reading and science content to be a good match for her students' abilities, and *Maryann* found the reading a good match while the science was a moderately good match for her class. *Maryann* saw a moderate amount of tie-in to other science activities, while Joyce saw this as a strength of the unit.

Both teachers would recommend the storybook to others, and Joyce would recommend the entire unit. *Maryann* indicated that she was not familiar enough with the unit to be sure if she could recommend it.

According to Joyce, the strength of this unit was primarily the literacy connection. The primary drawback was that some of the unit was difficult for third graders to understand. An additional challenge was the preparation time, especially in collecting items needed for the lessons.

Pat/Karen

EiE trained teacher *Pat* and her match Karen are teachers in their 50s with 5-8 years of teaching experience. Both are teaching a combined fourth and fifth grade and have advanced degrees in elementary education. This was *Pat's* first year of participation in any EiE-related activities. Karen was involved in EiE last year but had not had any training on using the three 2006/07 EiE units.

Teacher Engineering Attitudes and Activities

Before any training or exposure to EiE materials, *Pat* defined engineering as, “[s]olving problems with technology or mathematical concepts.” Karen, who participated in EiE the previous year, defined engineering as, “[d]esigning and building things using science.” *Pat's* use of engineering in her classroom included a cryptic mention of “electricity,” without further expansion. Karen indicated that she did no engineering activities in her classroom. Like most of the other evaluation study teachers, both *Pat* and Karen considered computer-related activities to be the technology they used in their classrooms.

Early in the year, *Pat* indicated that she would like to include more engineering activities in her classroom, saying that “[b]uilding a ramp for future careers is important.” In contrast, Karen was unsure as to whether or not she wanted to include more engineering content for her students, saying “I don't know anything about the engineering design process.”

At the end of the year, *Pat's* definition of engineering was, “[e]ngineering is a methodological approach to solving a problem.” In contrast, Karen's was, “[u]sing science to solve problems.” Karen indicated that she still was not doing engineering activities with her class, but *Pat* had taken her students on two engineering-related science trips to institutions near her school. *Pat* is also the only teacher among the

evaluation study teachers who changed her view of the use of technology in the classroom to include more than merely computer use. She and her class built a simple motor, which could also be considered engineering.

Pat and Karen are also the only pair of teachers who indicated, at the end of the year, that they would not like to include more engineering content in their classes in the future. *Pat* pointed to her state standards – “[i]t’s hard to do things that do not follow state guidelines” – while Karen wanted to have more information – “I would need more information so I understood the topics more.”

Engineering is Elementary Unit Implementation and Review

In her participation with EiE, *Pat* implemented all three EiE units in her classroom over the course of the year. Karen, as a match teacher, implemented none of them, but did provide unit reviews of all three. *Pat* was pleased with the literacy connections in all three units. Karen’s common critique of all three units was that they were not well differentiated for various ages or ability levels.

Bioengineering

Pat had her students read *Juan Daniel’s Fútbol Frog* independently. Karen indicated that she didn’t have time to read the book with her students, but that many of her students would be interested because of the soccer connection. Both *Pat* and Karen felt that the reading level was about right for their students, but while *Pat* indicated that the level of science content was a good match for her students, Karen found this to be less accurate. Similarly, while *Pat* found the opportunity for tie-ins with other science activities to be moderate, Karen found them less so. Both teachers, however, found the story engaging. As Karen wrote in her review, “[s]occer and frog? What’s there that a 4th grade boy wouldn’t like? I really think it would be interesting to them.”

Both teachers were appreciative of the inclusivity of the units. “Everything you need to teach the lessons is included (or materials spelled out precisely),” wrote Karen. *Pat* pointed out the preparation info and worksheets as particular strengths of the unit. *Pat* would recommend all sections of the unit, because “they all help cement the membrane concept.” Karen did not indicate whether she would recommend the unit or not.

Electrical Engineering

Pat read *A Reminder for Emily* with her class, and Karen indicated that, of the three units, this was the one she’s most likely to use in the future. Reasons they liked the storybook included that it illustrated how the materials worked, that electrical circuits are part of the 4th grade curriculum, and this is a good way to introduce the concepts.

Pat indicated a strong agreement that the level of the reading and science content were a good match for her students. *Karen*, however, found the reading content to be moderately well matched, but the science content was a good match for her students' abilities. Both teachers felt the tie-ins to other science activities with this unit were good.

Both teachers would recommend this unit to others due to its connection to the pre-existing curriculum, wealth of information, and its demonstration of the use of circuits in everyday life. *Pat* noted that her students had some confusion as a result of the use of some Australian terms in the storybook, but she felt that this may have helped her students identify more with the story in the end.

Acoustical Engineering

Pat read *Kwame's Sound* with her class. *Karen* did not do any of this unit's activities with her class, and had no plans to do so in the future. The primary strength of the storybook, from *Pat's* point of view, was that "Kwame is close to [my students'] age, so they could identify with him (somewhat)."

Pat found the levels of the science and reading content to be a moderately good match for her students' abilities; *Karen* rated the science content the same, but found the reading level to be a good match for her students. *Karen* indicated that the tie-ins to other science activities were moderate, while *Pat* found these to be good.

Both teachers would recommend the unit to others. They found the story interesting. Strengths of the unit included its inclusivity and the depth of the background. *Pat* wrote, "[i]t helped develop my understanding." With regard to weaknesses, in addition to *Karen's* overarching comment that the units were not well differentiated, *Pat* indicated that there was too much material.

Overarching Themes

All eight teachers participating in this aspect of the EiE evaluation completed the minimum requirements. They reviewed the three units and completed pre and post surveys. The four EiE trained teachers were required to complete at least one EiE unit in their classrooms. All four did, and two of the four implemented all three units. The non-EiE teachers were not required to implement any EiE units but were invited to do so. One non-EiE trained teacher implemented the three units in her classroom, while a second teacher implemented one unit. The other two teachers, including one who was trained in EiE the previous year, chose not to implement any EiE units.

Seven of the teachers began the year with an open attitude toward including more engineering content in their classrooms. The eighth teacher, the one who had received EiE training earlier but not in these units, felt that she would need to know more about engineering in order to decide whether she wanted to include more of it in her class.

At the end of the year, this teacher and her EiE match teacher both indicated that they would not like to include more engineering in their classrooms in the future. She continued to want more information about the topics and on how to teach engineering to her students. Meanwhile, her EiE partner teacher was worried about meeting state standards.

Their responses were quite different from the other six teachers, all of whom began and ended the year with a positive inclination toward including more engineering in future teaching. Three of these six teachers indicated that they liked the practicality and broad application of the engineering process, while the other three expressed their appreciation for the exposure it provided students to ideas about possible future careers and fields.

The two teachers, not trained in EiE, who implemented EiE units this past year, are planning to do so again. The teacher who did one unit, bioengineering, will use it again because it was a “[g]reat curriculum! Students enjoyed the lessons.” The other teacher, who did all three units, will do at least two units in the future. She felt that the “Electricity [unit] was a great extension on Magnets and Electricity; Acoustical was an extension to a 3rd grade unit on sound; Unsure about [doing] bioengineering – needs a lot of setup and cleanup.”

The third teacher did not use any units this year but stated that she:

...will definitely use [the units] in my [English Language Learner] ELL class next year.... because hands-on activities are highly effective for increasing language acquisition. I would like to use them in the mainstream classes but they are not aligned with a specific 8th grade standard so I would likely wait until the end of the year to make sure I have covered everything.

Teachers’ level of comfort doing the units seemed somewhat unrelated to the training. Trained and untrained teacher ratings of their comfort leading the units were comparable, with the exception of the one untrained teacher doing bioengineering. Comparable too were their ratings of the adequacy of their knowledge to do the lessons, again with the exception of the same untrained teacher who rated her level of knowledge less in bioengineering and electrical. Teacher ratings of their students’ success in completing the design challenges were comparable across teachers.

Overall, the EiE units seemed comprehensible, engaging, and doable to both trained and untrained teachers. Based on this small, matched sample, it appears that EiE training is not essential for teachers to understand and implement EiE units.