

Engineering is Elementary:
Impacts on Students Historically-Underrepresented in STEM Fields

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Introduction

The Engineering is Elementary (EiE) project developed curriculum materials designed to introduce elementary school students to engineering, and use that introduction to reinforce science ideas and provide motivation for learning science. A total of 20 units have been developed, each one focused on a different field of engineering. In each unit, students learn about the relevant field of engineering and the Engineering Design Process. Units begin with a storybook that introduces a problem that engineering can help solve, and feature boys and girls from a variety of race/ethnicity backgrounds. Units culminate with a design challenge that provides opportunities for students to use what they have learned to solve the initial problem.

The EiE units were purposefully designed to include a number of mechanisms to engage all students with the content. The units utilize science content students have already studied, which allows them to apply that content in a real-world engineering problem. In addition, the hands-on activities in the EiE units are designed around problems that are selected to be engaging and relevant to the students. The units also provide opportunities for students to try an idea, see how it works, and then try again. This process allows students who typically struggle in school to experience success. The units are also scaffolded so that later activities build upon earlier ones. This scaffolding allows students to build knowledge and skills in early activities, increasing the likelihood that they will be successful in later, more challenging activities. Finally, the activities are designed to be easily adaptable for students of different ages and ability levels.

Over the course of its work, the EiE project received anecdotal reports that the materials were particularly effective for students that traditionally were underrepresented or had underperformed in science, technology, engineering, and mathematics (STEM). In an effort to determine the extent to which this anecdotal evidence was representative of all teachers using EiE, and how these impacts came about, EiE commissioned Horizon Research, Inc. (HRI) to more systematically investigate the impacts of the materials on students historically underrepresented in STEM fields.

The investigation was comprised of two main components. To shed light on how pervasive these impacts are in the population of teachers using EiE, HRI developed a survey that was administered to a random sample of teachers using EiE in their classrooms. The survey asked teachers to categorize, for various underrepresented subgroups, their students' level of engagement and performance while using EiE as compared to science instruction and school in general. In addition, teachers were asked about the impacts the EiE materials had on students in a variety of areas and to describe in their own words the types of impacts they had seen.

The second component of the investigation was a set of ten case study interviews. Using the questionnaire data, HRI selected teachers for the interviews who reported that the materials had had a substantial impact on their students. In the interviews, teachers were asked to describe their use of the EiE materials, their students' level of engagement during EiE activities, the impacts they have seen as a result of using the EiE materials, and the features of the EiE materials they believe led to the types of impacts they described. This report summarizes the findings from the survey and subsequent interviews.

Survey Results

During the spring and summer of 2010, the EiE research staff administered a survey to approximately 350 teachers who they knew had used at least one EiE unit. Given available resources, it was not feasible to conduct intensive follow-up with non-respondents. Thus, a simple random sample of 75 teachers was drawn to target for follow-up. Achieving a high response rate with a sample should result in less response bias than a lower response rate from the population. Even with intensive follow-up, at the close of data collection, only 46 sampled teachers completed the survey, a response rate of 61 percent. Because the response rate is lower than hoped for, the results should be interpreted with caution, as they may not be representative of all EiE users. Appendix A includes a paper version of the survey.

Table 1 shows the responding teachers' experience with EiE.¹ Eighty-five percent indicated that they had used EiE for one year, and 80 percent reported using one unit during the 2009–10 school year.

Table 1
Teachers' Experience with EiE

	Percent of Responding Teachers (N = 46)
Number of Years Using an EiE Unit	
1	85
2	11
3	2
4	2
Number of EiE Units Used in Class This Year	
1	80
2	20

The survey also asked teachers to identify those sub-groups of students historically underrepresented in STEM that were represented by at least five students in their class. Of the teachers responding, 31 reported having at least five students from low-income families in their class; 22 at least five historically underrepresented minority students; 17 at least five with an individualized education plan (IEP), and 14 at least five English-language learners.

Teachers were asked a series of questions about the impact of EiE on these groups of students, as well as about females, who are also underrepresented in STEM. Questions focused on student engagement and performance with the EiE materials relative to other subjects, and student interest and performance in science and mathematics. For each group of students, the majority of teachers indicated that student engagement in EiE was higher than it was in science. For historically underrepresented minorities and students from low-income families, most teachers indicated that engagement in EiE was also higher than it was in school in general. (See Table 2.)

¹ All results shown from the survey are based on the 46 respondents who were part of the random sample.

Table 2
Teachers' Perceptions of Student Engagement in EiE
Compared to Engagement in Science and School in General

	Percent of Responding Teachers [†]				
	Much lower	Somewhat lower	About the same	Somewhat higher	Much higher
Engagement in EiE Compared to Science					
Female students	0	0	39	45	16
Students from low-income families	0	6	19	61	13
Historically underrepresented minorities	0	5	14	68	14
Students with an IEP	0	0	12	65	24
English-language learners	0	7	43	21	29
Engagement in EiE Compared to School in General					
Female students	0	0	61	32	7
Students from low-income families	0	6	35	48	10
Historically underrepresented minorities	0	5	32	50	14
Students with an IEP	0	0	53	41	6
English-language learners	0	14	43	21	21

[†] Percents are based on those teachers who had at least five students from the respective underrepresented group.

Responses to an open-ended item at the end of the questionnaire provided more information about students' engagement in EiE. Teachers were asked to describe, in their own words, the impacts the EiE materials had on historically underrepresented students in their class. The most prevalent theme was that students enjoyed, and were engaged during, EiE activities. For example:

I have observed my students become much more interested and engaged during the learning process. They reminded me about our scheduled science block activities on a regular basis. On the days that time prevented us from completing an activity related to EIE, they were disappointed.

My classroom is a mix of Hispanic, African American, and white students. They all were very interested in the unit and they had a wonderful time with the hands on activities. It engaged them and got them excited about science.

I thought the activities presented in EiE were very engaging overall. They provided learning opportunities that made difficult concepts come alive for my students.

Teachers were also asked about student performance in EiE relative to their performance in science specifically and to school in general. Overall, many teachers who had at least five students from one of the groups indicated that student performance for that group was higher in EiE than it was in science. (See Table 3.) The percent of teachers indicating students performed better in EiE than in school in general ranged from 30 to 52 percent, depending on the sub-group for which they were responding.

Table 3
Teachers' Perceptions of Student Performance in EiE
Compared to Performance in Science and School in General

	Percent of Responding Teachers [†]				
	Much lower	Somewhat lower	About the same	Somewhat higher	Much higher
Performance in EiE Compared to Science					
Female students	0	2	55	41	2
Students from low-income families	0	6	19	65	10
Historically underrepresented minorities	0	14	27	59	0
Students with an IEP	6	0	24	65	6
English-language learners	7	7	36	29	21
Performance in EiE Compared to School in General					
Female students	0	0	70	25	5
Students from low-income families	0	6	42	42	10
Historically underrepresented minorities	0	9	41	41	9
Students with an IEP	6	0	53	35	6
English-language learners	7	14	29	36	14

[†] Percents are based on those teachers who had at least five students from the respective underrepresented group.

Teachers also reported that using EiE had a positive impact on student interest in science, engineering, and mathematics, as well as student engagement and performance in school. As can be seen in Table 4, the large majority of teachers indicated that the use of EiE had at least a small positive impact in each area, with many teachers reporting a large positive impact.

Table 4
Teachers' Opinions of the Impact of EiE on Students

	Percent of Responding Teachers [†]		
	No positive impact	Small positive impact	Large positive impact
Interest in engineering			
Female students	5	43	52
Students from low-income families	6	48	45
Historically underrepresented minorities	9	41	50
Students with an IEP	6	59	35
English-language learners	14	50	36
Interest in science			
Female students	0	48	52
Students from low-income families	0	61	39
Historically underrepresented minorities	0	45	55
Students with an IEP	0	53	47
English-language learners	7	50	43
Interest in mathematics			
Female students	30	57	14
Students from low-income families	26	55	19
Historically underrepresented minorities	18	59	23
Students with an IEP	41	47	12
English-language learners	29	50	21
Overall engagement in school			
Female students	5	68	27
Students from low-income families	10	65	26
Historically underrepresented minorities	5	64	32
Students with an IEP	18	65	18
English-language learners	21	57	21
Overall performance in school			
Female students	7	61	32
Students from low-income families	16	68	16
Historically underrepresented minorities	14	59	27
Students with an IEP	29	53	18
English-language learners	21	57	21

[†] Percents are based on those teachers who had at least five students from the respective underrepresented group.

An open-ended question asked teachers to describe any impacts seen in their classes on historically-underrepresented populations as a result of using EiE materials. The responses help to illustrate the types of impacts seen on students' engagement and performance. Several teachers described how EiE developed their students' interest in and awareness of engineering. For example:

I think that in general their interest in engineering has gone up. They are more aware of engineers and what they do.

My students knew practically nothing about engineering or the science/math involved. Through the EIE curriculum, they gained an insight into their world and became interested in how things around them work.

In addition, several teachers described impacts that lasted beyond just their use of the unit, including increased interest and performance in science. For example:

I have noticed since doing the unit, the children have been much more interested in science and have become little inventors. They often can be seen drawing creations of new machines or gadgets that they have invented. It also encouraged my students to think outside the box and find the answer to a question through trial and error.

[Students have] much more interest in science. I don't know if it's a direct connection...but these kids did have a change in grades afterwards from proficient to advanced proficient in different areas...mostly math and science.

The students were much more engaged in school. They were interested in news events that dealt with engineering issues, such as the spring flood and the oil spill in the Gulf of Mexico. I saw them becoming active participants in class discussions and confident because they had background information that they were applying correctly.

Several teachers also took the opportunity to highlight the impacts they saw on students from specific historically underrepresented sub-groups. These responses, in general, focused on impacts on students' engagement. Examples of impacts on sub-groups include:

I see the same engagement level in EiE activities with underrepresented populations as I see with all my other students. I am not seeing the gaps that I see in other subjects. Underrepresented students are as capable in EiE activities as all my other students. I see the same excitement level while doing EiE activities in my underrepresented students as my other students.

After I taught the unit in submersibles, a Hispanic boy designed a ROV [remotely operated underwater vehicle] and did a science project for the science fair. He was the only one in the category of "invention." He didn't have support or money for supplies, so the results were not breath taking, but he couldn't stop talking about everything he read on ROV's, and he felt like an inventor and an engineer. It was very rewarding.

I feel the positive role model of the young woman in the Oil Slick story made a big impact for the girls. They can see that someone with a photography interest can use those skills in Engineering, that problem solving skills are something important and make Engineering look much less daunting.

Impacts on Historically-Underrepresented Students Interviews

In an effort to learn more about impacts the EiE materials are having on underrepresented students, HRI also interviewed 10 teachers.² Interviewees were selected from the pool of teachers who completed the impacts survey, (whether or not they were part of the sample of 75 teachers for the survey study specific to underrepresented groups), and had indicated they were willing to be interviewed. Using responses from both the closed- and open-ended items on the survey, HRI identified teachers who indicated substantive impacts on one or more sub-groups of

²HRI contacted a total of 15 teachers in order to get 10 interviewees.

students. Interviewees were then selected so that each sub-group of students would be represented by at least two teachers. The interviews sought to capture more in-depth information about the impacts of the EiE materials on the various sub-groups of students. Appendix B includes a vignette about each teacher that illustrates the most salient impacts that teacher saw on his or her students as a result of using EiE materials.

Teachers interviewed included regular classroom teachers, an engineering specialist, a science specialist, a classroom teacher who had also served as a part time engineering specialist, and a classroom teacher who had also served as a special education teacher. Of those teachers, more than half had been using EiE for three or more years (compared to about 1 in 6 of the teachers responding to the survey). In addition, most of the interviewees had used three or more EiE units in their classrooms (compared to less than 10 percent of the survey respondents).

During the interviews, the teachers described their students' interest in EiE activities and identified a variety of impacts on their students that they attributed to their use of EiE materials. In all cases, they indicated that their students enjoyed EiE activities, with most indicating that students enjoyed EiE more than they enjoyed school in general. Almost all the teachers interviewed reported that students learned more and performed better because of EiE. In addition, almost half reported changes in their students' work ethic as a result of EiE, including being more willing to work to improve their writing and working harder on challenging mathematics problems before asking for help. Several also indicated their students have been able to apply the skills they have learned in EiE activities to other contexts, including using the Engineering Design Process as part of a behavior management system in an effort to solve disputes that arise. For example:

Following the same process over and over and over again, using that Engineering Design Process throughout all the different kits and all the different grade levels, has a huge cumulative effect. The kids are able to break things down into steps. They're able to think about things, "Ok this is what I do first. I'm going to ask questions then I'm going to come up with a plan." They're really able to apply that design process, that problem solving skill, in lots and lots and lots of different areas.

In addition to impacts on students' performance, teachers reported impacts on students' attitudes towards school in general, and engineering and science in particular. Most interviewed teachers reported students were more interested in engineering and inventing following their experience with EiE, with just under half indicating that EiE helped their students realize they could be engineers in the future. Two said:

I think they're thinking of themselves as engineers or that engineering can be a possibility as a future. Every morning we have responsive classroom and have a morning meeting...and one morning I just said, "If you could do any career or any job that you would like when you're an adult what would it be?" And while you're still getting the baseball players or hockey players, that kind of thing, I was getting a lot of "I either want to be an engineer or a baseball player" or "I want to be an engineer or a football pro."

A lot of our students, especially in fifth grade, consider engineering as a career... I think the possibility of entering a science-related or an engineering-related field, I think our kids are much more open and much more positive about that than they ever were before. I think they're much more positive about just continuing in their K-12 education than they ever were before.

In addition, several interviewed teachers indicated that their students became more interested in science and several indicated their students felt more positively about school because of EiE. Similarly, several teachers described positive impacts on students' confidence as they experienced success with the EiE activities. For example:

Every kit is involved with such different experiences and yet they all involve the same basic skills so that every kit that we do, they're gaining confidence, they're gaining skills to apply to the next kit, even though they're not connected.

In addition to general questions about the impacts they had seen on their students as a result of using the EiE materials, interviewed teachers were asked to discuss which sub-groups, if any, seemed to benefit the most from EiE. In response to this question, half the interviewees pointed to special education students and students that typically struggle in school. When these teachers were asked to describe how these students benefited from EiE, responses varied, with the teachers pointing to such things as students being able to succeed without a high level of content knowledge, having the opportunity to experience success, and being fully involved group participants. Two said:

It really impacted...my lower students, my special ed. students, because they just seemed to feel like they could do it so they were willing to try and they didn't just shut down.

It's good for my EC [exceptional children] kids because they do have success...they tend to choose who they want to work with based on friendships not ability levels and so my groups are really mixed. At one table today I had an AIG [academically or intellectually gifted] student working with an IEP [individualized education plan] student and one of my just average [students]...and they were all working together and if somebody had walked into the room they couldn't have told the difference. So I think just that blending, letting the EC kids come in and just be part of the group, is real important. They're not standing back; they're not watching others succeed where they can't.

In addition to struggling students, nearly half the interviewed teachers indicated that their female students had benefited greatly from EiE activities. Teachers pointed to such things as requiring the girls to participate fully and showing them they could keep up with the boys in science and mathematics. In addition, teachers reported impacts such as increased leadership and an increased willingness to take risks as a result of their female students' experience with EiE. Two described impacts on female students as follows:

Maybe not the very first EiE unit we did, but definitely by the second one, I saw that the girls were willing to step out and try to figure out the problem. And if it didn't work, instead of just either giggling and saying "Oh I can't do this" or being silly or just not

even trying, they would try again. I saw them multiple times trying to figure out why it didn't work and come to an end result. And then I also would see that when I would have them present to the other groups they were confident in what they were presenting so they would present effectively and do a nice job with it. So it sort of seemed to bring them out of their shell and just show them that they could take risks and it was ok.

I have one young lady who at the beginning of the year she was real quiet. She kind of hung back... [Now] I see her taking over the group whereas at the beginning of the year she was more laid back, she would just kind of wait and you could tell she wasn't sure about herself, she didn't have that confidence. Now I see her... maybe not leading the group so much as at least getting her point across. If she sees something that needs to be done she'll speak up. She doesn't sit back anymore; she's got her hands in the materials, she's trying things out and she's making suggestions.

In order to gain insight into what may be leading to the impacts teachers see, interviewees were also asked what they saw as the benefits of using EiE and what aspects of EiE they believed led to the impacts they reported. Almost all of the teachers interviewed believed the teamwork involved with EiE was a factor. For example:

There's a lot of teamwork and cooperation that kind of made it more fun, like the assembly line part was a lot of fun for the kids, and then the actually working the simple machines was a lot of fun for them.

In addition, most of the teachers interviewed indicated that the EiE materials gave all students a chance to succeed, noting that the activities are hands-on, are scaffolded, and allow teachers to differentiate to meet the needs of all of their students. Other common responses included the open-ended nature of the problems, the opportunity for students to think for themselves and use their creativity, and the well-rounded nature of the units which incorporate multiple subject areas as well as relevant, real-world problems. As four said:

It's tiered and it's structured and it's scaffolded and... as a teacher you can even scaffold it more so that you can give it to them in manageable steps. And I think that makes them more confident that if they have the first step they can build onto the next step. So by the time it gets to the third part, where they're trying to solve a real problem, they've had examples, they've had steps, they've done different things with the materials and I think they just feel that confidence then to go further.

It's the hands-on with the possibility of becoming successful, that there is no failure. You keep telling them that failure is only because you chose to quit, not try a little harder to get something else out of it, that you're successful for just trying.

I think that it does require you to be trying to solve something and I don't know if we've done that with kids all that [much]. I think if you think of science you did an experiment and everyone comes up with the same answer. I think there's something about that "Oh we can be creative. We can come up with our own ideas. We use what we're learning from that first test we've done and then improving it." So you're trying to get that "I

can do better.” And I think that’s kind of freeing not to have there’s a right answer or a wrong answer to this.

Because EiE has the literature component and you can sort of incorporate it throughout your day I think it’s richer and you get more continuity with it. I love the literature, I love the stories, and I always love that...it’s either from a different country or [the character] might have a disability, but it was just different things that we could discuss as a class and talk about.

Summary

The survey and subsequent interviews provide information about the extent and nature of impacts of the EiE program on students who are historically-underrepresented in STEM fields. Although neither the survey respondents (because of the low response rate) nor the interviewees (because they were selected as best cases) can be considered representative of all teachers using EiE, some common themes emerge from looking at both sets of data. In both, teachers indicated their students enjoyed, and were engaged during, EiE activities. Many teachers indicated that student engagement was higher with EiE than in either science or school in general for at least some sub-groups of students. In addition, teachers indicated students’ experiences with EiE led to positive impacts on their performance in school, as well as on their attitudes towards engineering, science, and school in general.

Appendix A

Impacts on Students Historically Underrepresented in STEM Survey

EiE Impacts on Underrepresented Students Survey Items

Name: _____

1. In how many different school years have you used at least one EiE unit?

- 1 2 3 4 5 6+

In Questions 2-7, we are interested in learning about the impacts EiE is having on students from populations historically underrepresented in science, technology, engineering, and mathematics fields. As you answer these questions, please think about the students in your class this year. If you use EiE units with more than one class, please think about the first class with which you used EiE this year.

2. How many EiE units did you use with this class?

- 1 2 3 4 5 6+

3. Of which of the following groups did you have at least five (5) students in this class? (Select all that apply.)

- Females
- Historically underrepresented minorities (i.e., Hispanic, American Indian or Alaskan Native, Black or African-American, Native Hawaiian or Pacific Islander)
- Students from low income families
- Students with an Individualized Education Plan (IEP)
- English-language learners (ELL)

Questions 4–7 ask about impacts of the EiE units on these groups of students. Do not complete the column for any group that you did not have at least five (5) students from in this class.

4. How did your students' engagement in EiE compare to their engagement in:

	Females					Historically Underrepresented Minorities					Students from Low Income Families					Students with an IEP					Students who are English Language Learners				
	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE
a. Science in general	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. School in general	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. How did your students' performance in EiE compare to their performance in:

	Females					Historically Underrepresented Minorities					Students from Low Income Families					Students with an IEP					Students who are English Language Learners				
	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE	much lower in EiE	somewhat lower in EiE	about the same	somewhat higher in EiE	much higher in EiE
a. Science in general	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. School in general	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. What impact has using EiE had on your students':

	Females			Historically Underrepresented Minorities			Students from Low Income Families			Students with an IEP			Students who are English Language Learners		
	no positive impact	small positive impact	large positive impact	no positive impact	small positive impact	large positive impact	no positive impact	small positive impact	large positive impact	no positive impact	small positive impact	large positive impact	no positive impact	small positive impact	large positive impact
a. Overall performance in school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Overall engagement in school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Interest in science	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Interest in mathematics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Interest in engineering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. In your own words, please describe any impacts you have seen on students, in this class, from historically underrepresented populations as a result of their experiences with EiE activities in your classroom.

Would you be willing to be interviewed about the impacts you have seen on students as a result of their experiences with EiE?

- Yes
- No

If you are willing to be interviewed, please provide your email address and/or phone number.

Email address: _____

Phone number: _____

Appendix B
Case Study Vignettesⁱ

ⁱ Pseudonyms are used to protect teacher identities.

Vignette 1

Making Science Relevant and Opening Students' Eyes to Engineering

Ms. Johnson teaches Kindergarten in a school with a high percentage of minority and economically disadvantaged students; prior to this year she had spent the majority of her career teaching first grade. According to Ms. Johnson, most of her students did not attend pre-school, and do not have a lot of parental support for school. Ms. Johnson indicated that teachers in the school work hard to ensure students succeed, though some students still struggle to pass the state tests.

According to Ms. Johnson, her science and EiE instruction are similar, with students doing a lot of hands-on activities in both cases. In the four years Ms. Johnson has used EiE, she has implemented three different units. Ms. Johnson indicated she usually uses kits supplied by the county to first teach the science content, and then has students apply that content through activities in an EiE unit.

Through her experiences implementing EiE, Ms. Johnson has seen several impacts on her students. She indicated that EiE has taught her students perseverance, teamwork, and problem solving skills. She also believes her students have a greater understanding of science because of EiE. In particular, because EiE has students apply science content to solve problems, Ms. Johnson believes students view science as more real and relevant:

I think the problem solving piece, and the fact that they're applying the science concepts to actually building something or designing something, just makes it more real to them. It's not just looking at it out of a book.

In addition, Ms. Johnson believes EiE has impacted students' interest and engagement in engineering. She indicated that students in the school are referred to as "Student Engineers" so they start to see themselves as engineers and problem solvers. As a result, she believes students are more aware of engineering and more likely to pursue engineering later in school. Ms. Johnson described the impact on her students' awareness of engineering as follows:

A lot of the children I teach would never have even heard the word engineer much less think about the fact that they could be one. So definitely, I would say for the minorities it has opened up a whole new world for them.

In addition, Ms. Johnson indicated that students in the school apply the Engineering Design Process in other areas, including behavior management. She described how the Engineering Design Process is applied to behavior management as follows:

We'll say "Ok, what's the problem here?" and we'll work together, in either a small group or even sometimes the whole class, to kind of brainstorm ways to solve the problem. And so we just kind of go through the same process and then if it's still not working, there's still a problem, "Ok we have to change it and do something different." The design process is kind of engrained in them, especially by the time they get all the way through fifth grade, in how to solve problems in an effective way.

Vignette 2 Showing the Value of Teamwork

Ms. Anderson teaches science to two different classes of fifth graders in a school with a high percentage of students who receive free or reduced-price lunch assistance. The school is designated by the state as a “school in need of improvement,” with many struggling students. Her classes are typical of those in the school. In the four years she has been using EiE, Ms. Anderson has used a total of five EiE units.

Ms. Anderson believes that science instruction should make sure students master the targeted content. She prefers to use hands-on activities to teach science, but noted that many hands-on activities out there are content free. Over her four years using EiE, she has taught four different units. She likes using EiE because she believes the activities in the units incorporate content appropriately.

Through her experiences with EiE, Ms. Anderson has seen several impacts on her students. She believes students have been able to integrate engineering, specifically the Engineering Design Process, into their way of thinking. Ms. Anderson indicated she discusses using the Engineering Design Process in other subjects as a way to solve problems. She also believes students have been able to relate how engineers think about and work with things to other topics in her class. In addition, Ms. Anderson believes EiE helps students understand how the basic skills they are learning in school are relevant in other areas, and believes that students’ attitudes about school have improved as a result. As she said:

I do think that they see things in a more positive way; that the basic skills that they need in terms of math and writing and communicating all do go into the science. So those kids who may think that they read well, or they're good in math, and that has nothing to do with anything else, now there is a connection, and there is a need to have those basics to do other things.

Ms. Anderson also believes that EiE has developed her students’ ability to work as part of a team and to cooperate with others. She indicated that EiE provides authentic opportunities for students to work together and has observed students talking through problems more often in EiE activities than in other group work in her classroom. In addition, because students need to create a product for the design challenge at the end of the unit, Ms. Anderson believes they develop an “intrinsic desire to cooperate” so that they can complete the task. Ms. Anderson gave the following example of a group that initially spent a lot of time arguing but managed to come together for the design challenge:

The [unit] that we just did on the knee brace, one group really was not going anywhere. They were pretty much bickering constantly and would start something and didn't like it. Planning again is not one of their real strengths; they get this plan written up and decide they're not going to look at it anyway. And when they presented their knee brace, they said themselves that they really didn't think that they were going to ever get anything finished. [But] they did, and they were proud of themselves. They looked at each other as if they'd been a team that had to solve this problem, they did, and it was good, and they were happy... And I think they also saw that in the end, they really couldn't pick out who had done what...that's a huge step in terms of team building.

Vignette 3

Giving Low-Achieving Students an Opportunity to Shine

Ms. Thomas teaches a very diverse fourth grade class, with students from a variety of races, special education students, and English-language learners. According to Ms. Thomas, her students tend to struggle with science and mathematics, especially when instruction does not involve manipulatives and hands-on activities. She indicated that the boys in her class tend to perform better than the girls, but that all of her students were hard-working.

Ms. Thomas described her regular science instruction as very textbook-based, including a lot of reading and vocabulary. She tries to include some hands-on activities in her instruction, but because she does not have access to science kits, these activities tend to be relatively short. With EiE, however, Ms. Thomas reported that students are able to do more hands-on activities and problem-solving. In addition, Ms. Thomas incorporates EiE into literature and social studies. She uses the storybooks included in the units for whole group and small group work during her literature instruction. For social studies, she teaches students about the country featured in the storybook, and ties its location into geography lessons. As a result, she believes students think of EiE as a normal part of the day rather than a separate subject.

Ms. Thomas attributes a number of positive impacts on her students to EiE. She believes that students work together more effectively because of their experiences with EiE, and that students have become interested in engineering. Ms. Thomas also reported an improvement in her students' work ethic, and, particularly for her female students, an increased willingness to take risks. For example, she has noticed that students put more effort into answering higher-level science questions, and that they try harder on state tests, taking them more seriously. In addition, she has noticed that students now work harder on more challenging problems in mathematics, trying to find a solution rather than immediately asking her for help. Ms. Thomas described a group of her lower level students who typically got easily frustrated and stopped trying. After experiencing EiE, Ms. Thomas noticed that these students worked diligently on a PowerPoint project as they tried to figure out how to accomplish what they wanted. She described that group's work and how EiE contributed to it as follows:

They did a PowerPoint project as part of their technology, and they were researching the Sun and solar system and some of the effects that the Sun has on people...And the one little group that I'm thinking of was actually all of my lower students, so it was four of them, and they were my Special Ed students, and usually struggled and usually would get frustrated and sort of quit until they were prompted. But this project was after we had done two EiE units...and they worked together tremendously. I mean even when they would get stuck on a part of a PowerPoint and not remember how to do something, or if they wanted to add animation, they worked together, they talked it through and if they couldn't figure it out then they would go ask an adult for guidance or help. And the other thing was just the dialogue between them was rich and the end project was comparable, if not one of the better ones in the class...and you could just see how proud they were of it. So I think that was a huge part due to EiE because of what's required with it and because they figured out that they could do it and work together effectively.

In addition, Ms. Thomas noted that students were especially excited to do EiE and tended to be more engaged in those activities. She cited one student in particular who tended to put little effort into his work in other subjects, but was very engaged with EiE and even wanted to do additional research on the unit topic. She believed that the hands-on activities, and the art that was incorporated in that particular EiE unit, were what motivated that student. She also indicated that this student's enthusiasm motivated other students, and that he was able to help them with the activities. She said:

There was one little boy that I had...and he was very hesitant to engage. Just basically if he could skate by he would skate by, he wasn't going to put any effort into it, [and] definitely could be a disruption if you allowed him to be...But by the time I had him last year in fourth grade, that's where I definitely saw a change, especially with the one [EiE unit] that we were doing. They were making petroglyph carvings on the rocks and they each got to do their own, and he was really engaged and excited about it and then actually wanted to do some research on petroglyphs and find out a little bit more about them...He was so engaged, he was sort of motivating to some of the [students] that were struggling... and he just really worked with them and did his best, and it was the first time I had really sort of seen that.

Vignette 4

Provided Opportunities for Success for both High-Achieving and Struggling Students

Ms. Jackson teaches a first grade class of students that includes a high achieving student (who ended up skipping second grade) and several students with IEPs. However, she indicated that most of her students were “average,” but “fairly articulate.” According to Ms. Jackson, her students tend to enjoy science, especially hands-on activities. In the one year Ms. Jackson has used EiE, she has been able to implement only one unit, though she wishes she had more units available to use. Ideally, she would like to have one unit for each trimester, but indicated the school has not had the funding to purchase additional units. She likes that the units get students involved in activities and are student-centered, providing opportunities for students to work together, think for themselves, and come up with their own designs.

In her science instruction, Ms. Jackson uses a combination of kits and self-developed units, generally including a lot of hands-on activities. When comparing her regular science instruction and her instruction with EiE, Ms. Jackson indicated her science units tend to cover more ideas in less depth, while EiE units tend to focus on fewer ideas but cover them in more depth.

Ms. Jackson attributes several impacts on her students to their experience with the EiE unit, including that her students’ performance in science and school was better as a result. She noted that students had a better understanding of how to build stable structures after completing the EiE unit. In addition, she indicated that prior to EiE, students were not willing to make careful records of their work. However, because of their experience with EiE, which required students to record their observations and results of experiments, students learned the value of documenting their work, which carried over into the future science units. In her own words:

The rest of the year, they seemed to be more interested in writing things down after they had done an experiment. Sometimes with first graders, they love doing the experiments but they don’t like writing anything down. But after [EiE]...they were sort of used to doing that. So when we did some of our other units, they were much more apt to make drawings and write about what they’d done.

Ms. Jackson believes that the experience with EiE was especially important for her students at the two ends of the achievement spectrum. One of her high achieving students, was so excited about engineering, she joined an engineering activity at the [science museum] during a trip there with her family following the unit. As the teacher said:

[She] went down to the [science museum] after our engineering unit and [found] some engineering thing going on at the museum. And she joined right into that and was very excited about that. So I think [the unit] probably meant a great deal to her because she was able to follow up with that at the museum.

In regard to her lowest ability students, Ms. Jackson believes EiE gave them an opportunity to feel respected and successful. She noted that one student in particular was able to demonstrate maturity and focus on the activities, which she thought was especially good for him. When asked what about EiE enabled the student to focus and show maturity, the teacher pointed to students being expected to do their own thinking and make their own decisions about how to solve a problem, as well as justify why they are taking that approach. In describing how EiE impacted her lowest students, Ms. Jackson said:

I think those lowest kids, the ones that find learning difficult, having the opportunity to feel respected and to be part of a design team and to work together to make something come out right. It really benefited those kids that aren’t as strong academically.

Vignette 5

Changing Students' Ideas about Technology

As an early elementary teacher, Mr. Davis implemented an EiE unit on simple machines with a class with a high percentage of minority and economically disadvantaged students. He described the students as “average to below average.” According to Mr. Davis, the students tend to enjoy science and be motivated in science because of the activities they do.

Mr. Davis indicated that instruction in his school tends to be textbook-driven with a heavy focus on multiple-choice assessments and preparing students for standardized tests. He believes EiE provides a nice break from their typical routine and noted that he appreciates that EiE involves hands-on activities and includes a literature connection.

In reflecting on his use of the EiE unit, Mr. Davis indicated his students benefited from being able to work with and manipulate simple machines. He believes simple machines are normally abstract concepts to the students, but the hands-on experience provided by the EiE unit allowed them to better understand the content they were learning. In addition, he believes students retained what they learned because of those hands-on experiences, and indicated that his class' scores on the state science test greatly increased that year.

He also indicated his students were especially excited about the activities in the unit, particularly the design challenge, which he attributed to them seeing the challenge as a competition and feeling free to design their own solutions. In describing their excitement, Mr. Davis said:

They were always anxious to get started...I think it's just because they saw a physical problem and they were able to figure out how to do it versus...reading a book. It was right in front of them, it was very visual and tactile, so they actually could see it, manipulate it, and that...kept their interest and increased their motivation to be successful.

Mr. Davis also indicated the “Tech in a Bag” activity provided in the EiE unit had a big impact on students. He reported that the activity changed students' ideas about technology making them realize that not just electronics are considered technology. In addition, he believes that, because of this activity, students became excited about the idea that they could be inventors with some even trying to think of ways they could improve common classroom supplies. As Mr. Davis described:

I know one thing that was very fascinating for them was, when we had the little paper bag activity where you were supposed to put all this different technology in it. And a lot of them had the strong opinion that technology is electronic and when you put like a tape dispenser in there or a pencil they were fascinated by the concept that technology is not necessarily everything with a battery in it. So that was a huge impact on their learning about what technology is and how to improve things. That got them excited about how they could possibly be inventors themselves and solve problems.

Vignette 6 Opening New Worlds to Students

Ms. Jones teaches fifth grade in a school that follows a nine-week rotation for social studies, science, and engineering instruction. Each cycle, students spend three weeks each doing social studies, learning science through a kit provided by the county, and working on an EiE unit that complements the science kit. The school has a high percentage of minority students and a high rate of poverty. In fact, all of Ms. Jones' students receive either free or reduced-price lunch assistance. Ms. Jones indicated that students' experiences outside of school are limited, and many are unable to visit even nearby local attractions because they are not located on the city bus line. Although the class has a wide range of abilities, including gifted students and students with IEPs, Ms. Jones indicated that most of the students were "average," typically receiving grades of C and above.

Ms. Jones believes that her style of teaching complements EiE. She indicated that much of her instruction involves small groups and hands-on exploration, which her students tend to enjoy. Ms. Jones has been a self-contained classroom teacher and used EiE for two years; prior to that she served as a special education teacher and supported other teachers with their EiE instruction.

Through the use of EiE, Ms. Jones has seen a variety of impacts on her students, especially more positive student attitudes towards academics. Early in the year, students were asked to write three goals for themselves; they then revisited and updated those goals after New Year's. Ms. Jones was pleased to see that students' updated goals were academic in nature despite the openness of the assignment. She also indicated that high school graduation has become a theme in her classroom. She described her students as focused on getting into middle and high school classes that will allow them to graduate high school with a two-year college degree. Ms. Jones believes this impact is due to the success student experienced with EiE, which has students use engineering skills to solve different problems. Because they are able to successfully apply these skills multiple time, students' sense of self-efficacy increased.

She has also seen a change in students' career aspirations. Prior to using EiE, when asked what they wanted to be when they grew up, students would cite jobs such as being a Wal-Mart greeter. Students did not see career options for themselves that went beyond the opportunities in their own neighborhood. Now that students have experienced EiE, Ms. Jones believes they are more likely to consider going to college and pursuing careers in engineering or technology. Ms. Jones indicated that her students' confidence, perseverance, and ability to problem solve has increased. She also noted that EiE has helped them develop a larger scientific vocabulary.

Ms. Jones stressed the fact that EiE "levels the playing field" by providing opportunities for all students to be successful. She indicated that, in EiE, students are able to work effectively in mixed-ability groups, compensating for each other's weaknesses and building on each other's strengths. Consequently, everyone in a group is able to participate productively. As she described EiE:

It really levels the playing field...If you walk into my classroom, you see these kids working together. You can't pick out the special ed. kids, and you can't pick out the AIG [academically or intellectually gifted] kids. Because number one they work together really well as teams, but they also each bring strengths to the table that compensate for each other's weaknesses. This child may not be able to read well, but boy he can match up the nuts and bolts of things and put it together and build. They really, really work well together and build on each other's strengths which I think is really, really unique and makes them all feel successful.

Ms. Jones believes several aspects of EiE lead to the impacts she sees. She thinks students find the units engaging because they involve hands-on activities. In addition, because each unit features a different field of engineering and a different country, she believes the students remain interested from unit to unit and learn about different places and professions, which broadens their horizons. In addition, she indicated that the Engineering Design Process shows students that they are not failures if they do not succeed on the first try. Instead she believes students learn to improve on their initial attempt which helps them develop perseverance and helps them realize that they can succeed in more complicated tasks. As Ms. Jones explained:

When you first present them that problem, it's such an unknown. But when they get their hands on the materials and they start applying what they've learned previously, it's really, really fun to watch their faces light up and realize, "Oh I can do this. Oh I learned this last time, I can apply it here." ...So many times our children are in situations where they fail and they give up and I think that the Engineering Design Process feeds into that efficacy, makes it possible for them to believe that just because they don't make it the first time, the first attempt, it doesn't mean they're a failure it just means, "Hey I need to step back, I need to analyze it, what can I adjust, and let me try this again." ...I think it gives them that stick-to-itiveness that helps support that efficacy.

Vignette 7

Encouraging Students to Revisit and Refine their Thinking

Ms. Harris is a regular classroom teacher in a school with students she describes as “typical small town kids.” The students in her class are heterogeneously mixed, and include two “special needs” students and one English-language learner. Ms. Harris indicated her students tend to be strong in mathematics and generally enjoy science.

Ms. Harris uses EiE units that tie into her regular science instruction. She indicated that science instruction is very similar to her instruction with EiE in that both involve the students in a lot of exploration. In the four years she has been using EiE, she has used a total of five different units. Ms. Harris indicated that her students enjoy EiE, especially the hands-on aspect. She believes the experiences students have with EiE are especially important because she views engineering and technology as “up and coming” fields. She believes it is important that students learn how to design something and rework it to make it better.

Ms. Harris attributes several impacts on her students to EiE. One impact has been on students’ attitudes towards science and engineering. She gave the example of a special needs student who, because he was able to experience success with the design challenge in the *Designing Lighting Systems* unit, was motivated to improve his science writing. Ms. Harris also believes EiE teaches students that just because they do something once, it does not mean they are finished. She indicated that through EiE, students realize they can learn from, and improve on, their initial attempts.

Ms. Harris also noted that she thinks EiE is especially beneficial for atypical students. Ms. Harris believes EiE allows special needs students to experience success, even though they do not have a lot of content knowledge. She said:

You don't have to have a high level of content of what's going on because you can actually get in there and experiment...If something didn't work then they would go back and try and test it again and they didn't have to be top students to be able to do that.

Similarly, she thinks the open-ended explorations involved with EiE are beneficial for high-achieving students. She indicated that those students tend to have ideas they are not given the opportunity to test in typical classroom instruction, but can when they use EiE. She described the benefits of EiE on high achieving students as follows:

Sometimes their ideas are out there and they're not ever allowed to [pursue them]. And I think that the EiE allows them to be able to do some of those far out ideas, and sometimes they work and sometimes they don't. But it allows them to step outside the regular classroom “you have to do this, this way” and challenges them.

Vignette 8

Using the Engineering Design Process to Improve Students' Writing

Ms. Farmer teaches a racially-diverse third grade class. In her school, students are heterogeneously mixed, and her class includes special education students, gifted students, and English-language learners.

Ms. Farmer has used three different EiE units across her three years using the program. EiE units are selected to complement her science units, some of which are kit based and others of which are textbook based. In addition to her experience implementing EiE in her own classroom, Ms. Farmer has served as a half time engineering teacher. In this position, she has modeled how to implement EiE units for and assisted other teachers with implementing EiE in their classrooms.

Through her experiences with EiE, in her own and in other teachers' classrooms, Ms. Farmer has seen a variety of impacts on students. She indicated her students really enjoy their experiences with EiE and are even willing to give up recess so they can spend longer working on their designs. Because students enjoy EiE activities, she believes that the EiE units cause students to consider engineering as a possible career path, stating that boys in her class now consider being an engineer as an alternative to being a professional athlete. In addition, she attributes greater student enjoyment in school to the opportunities they have to be creative, solve problems, and experience success in the EiE units.

Another impact has been increased student confidence. Ms. Farmer has seen this increased confidence when students explain to adults the approach they took and their rationale in meeting a design challenge. This impact is particularly evident for students who struggle in other content areas. Because EiE requires students to use creativity to solve problems, even students who struggle academically are able to contribute meaningfully to the work, earning the respect of their classmates. As an example, Ms. Farmer described one of her students who was often pulled out of the classroom for remediation. She described him as very quiet and timid because he believed he was not intelligent. However, during the *Designing Walls* unit, the student insisted that his group try his idea, eventually convincing them to follow his advice. The group found that his design worked, which bolstered his confidence. As Ms. Farmer described:

He was adamant that they needed to change to his method because he was sure he was right. And he was right, and his first grade teacher was in the classroom during that and she was like, "I was just amazed," because he had typically been more quiet and didn't have the power in the classroom ...She was amazed at how he just changed his whole personality and it made him very strong. And the kids found out later and were cheering when we did the demolition ball and theirs withheld and he said, "I knew it. I just knew it."

Ms. Farmer has also seen the EiE process of trying something, improving it, and trying again, being carried over by her students into other subject areas. For example, prior to EiE, students did not like editing and improving their writing. However, through their experience with EiE, they realized rewriting and editing, like the "improve" step in the Engineering Design Process, helps them make their writing better. As a result, Ms. Farmer indicated that students are now willing to put more effort into revising and improving their writing. She said:

You teach writing all the time, and you try to get them to edit and improve it. And they're like, "No, I'm done." I think this EiE really gets them to think that a problem is never totally solved because there are always other ways you can keep improving on it. And they actually related that to the writing process and went, "Oh my gosh, this is why you rewrite and this is why you edit, you can make it better." ...So I have seen it carry over even into other curriculum areas.

Vignette 9

Using Engineering as a Hook to Encourage Struggling Readers to Read More

Mr. Williams is in his second year as a science specialist in a school where students tend to come from “strong family backgrounds.” Most of the students in the school are white, with approximately one-quarter minorities, mostly African-American. Mr. Williams teaches science and engineering to third, fourth, and fifth grade students. According to Mr. Williams, students tend to be enthusiastic about school and eager to learn.

Mr. Williams indicated that EiE fits in nicely with his style of teaching. He teaches science using a combination of FOSS kits and materials he developed, incorporating a lot of hands-on activities and some engineering activities. Because his teaching approach is so similar to the one in EiE, Mr. Williams found it difficult to tease out how much of the impacts he saw on his students are due solely to EiE. According to Mr. Williams, students were especially enthusiastic about the idea that, in engineering, they have the opportunity to improve on their initial designs. In addition, he indicated that students’ performance on state science tests improved, with twice as many fifth grade students passing the test his first year compared to the previous year’s fifth graders. Mr. Williams believes the hands-on activities students experience contributed to their enthusiasm and increased their retention of content, which contributed to the improved performance on the state tests.

Mr. Williams believes EiE is especially beneficial for struggling readers because the hands-on experiences get them interested in a particular topic, which then encourages them to read about that topic. As an example, he described the experience of one student who was unenthusiastic about science and struggled to read. Mr. Williams indicated that the *Designing Submersibles* unit got the student so excited about submarines, he checked out a book from the library so he could learn more. Mr. Williams went on to describe how the student’s reading ability has improved to “almost at grade level,” indicating that the teachers have continued to use the student’s interest in engineering as an avenue to help him improve his reading. Mr. Williams described what he saw as the benefits of EiE for struggling readers as follows:

Having this hands-on stuff...they get interested in science, and then they're picking up the books, and maybe now they're going to increase their reading. There's a direct correlation between the hands-on science and reading tests; the more hands-on science you give, the higher the reading scores will go up too, because kids have an enthusiasm for the knowledge that they're being presented at that point. And EiE does that. It does give them some of the background they need to have to want to investigate more into reading a particular subject material, like on submarines and what makes them float, what makes them sink, weight factors, buoyancy.

In fact, he indicated that more students checked out science books after using EiE than at any other time, “That says that they’re willing to read science.”

Vignette 10

Engineering Helps Keep Struggling Students in School

Ms. Wilson is an engineering specialist in a school with a high percentage of minority students. The vast majority of the students receive free or reduced-price lunch assistance. According to Ms. Wilson, students often struggle with basic reading and math skills. She indicated that students typically do not do their homework or anything more than the minimum requirements, though they do tend to enjoy science.

Ms. Wilson indicated that her school has been using EiE for four years. Teachers first use hands-on kits to teach science content, then have students apply that content through related EiE units. As the engineering specialist, Ms. Wilson is involved in a variety of ways with implementing the EiE units. In some cases, she implements the kits on her own with no help from the regular classroom teacher. In other cases, she teams with the classroom teacher, with one of them serving as the lead teacher while the other one assists with management or works with a sub-group of the class.

Ms. Wilson believes EiE has had positive impacts on the students in her school, including being responsible for the substantial increase in scores on state tests over the past three years. She also believes students feel more positively about education and are more likely to consider pursuing science or engineering careers because of EiE. She notes that having students use the Engineering Design Process across multiple units has increased their problem-solving abilities, and indicated that they are applying the Engineering Design Process in other areas as well as they break problems down into steps and create plans to solve those problems.

Ms. Wilson described a variety of impacts on her students, the most salient being increases in their motivation and confidence. She indicated that the hands-on, open-ended activities in EiE give students who normally struggle a chance to experience success. As a result, she believes those students become more motivated, confident, and positive about school. As Ms. Wilson said:

For the students that we have here at this school that typically perform at or below grade level, the engineering, the EiE curriculum, allows them to succeed at school. Kids typically who have failed every single test, they'll come to school here and they will start having success with hands-on projects. It increases their motivation, increases their self-confidence, which in turn increases their whole attitude about school.

Ms. Wilson illustrated the impacts she sees on students' confidence and attitude towards school when she described a student who came to her school as a fifth-grader unable to read and struggling with mathematics. Early in the year, the student was frequently absent and suspended from school. As the year has progressed, Ms. Wilson has noticed several changes in the student's behavior which she attributed to the success he had with EiE. She described how the student's attendance and behavior have improved dramatically, and noted that he has not been suspended since the first quarter of the school year. She also said he no longer shuts down completely when he struggles in other subjects. She described the changes she saw in the student as follows:

He is really, really, really struggling with reading in fifth grade...He's able to do math computation, but it takes him a long time; he still has to count on his fingers when he adds and subtracts. When it comes to the EiE projects, he is a star in his classroom. His ability to brainstorm and plan things, his drawings in his engineering notebook are phenomenal. They are full of detail and he can look at things from different perspectives, like he can draw a side view or a top view. And he's the kid that everybody wants in their group when it's time to do an engineering project but he can barely read. And this, the EiE, being able to participate in activities in school and be a leader in those activities because of his creativity and his abilities to see things differently has increased his self-confidence a thousand-fold...And at the beginning of the year, when he would struggle with something in reading or math, he would become very silent and obstinate and he would cross his arms and say "I'm not doing it" and he would sit there. And he has gotten up and walked out of a classroom once or twice, walked out of after-school tutoring once or twice. Since he has been engaged in hands-on engineering activities and shown great potential in those and been a leader, he does not do that... We've established a really good relationship, doing engineering activities, and so I can even help him with math and reading now.