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Museum of Science: Engineering is Elementary

Exploring the Impact of EiE on Participating Teachers

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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 school aged 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 should be able to implement EiE without professional development workshops.

To begin to look at the impact of EiE training on teachers, those teachers who attended EiE training during the summer or fall of 2006 were asked to complete pre and post surveys focusing on both their definitions and use of engineering and their classroom instructional strategies. Pre/post surveys were received from 24 EiE teachers, including twelve Minnesota teachers, five Colorado teachers, four Florida teachers, and three California teachers. The following is an overview of the results:

After participating in EiE, teachers significantly increased their use of engineering in their teaching in both science and other content areas.

Teachers were asked in eight different ways to rate the degree to which they used engineering in their classrooms. Based on EiE's goals, it was hypothesized that teachers' use of engineering in their classrooms would increase. As seen in Table I, this did indeed happen. Teachers' use of engineering increased in all eight areas. Particularly large increases were found in the frequency with which teachers described engineering careers to their students, used engineering examples in science lessons, and, most impressively, used an engineering design process in their science classes. They were also significantly more apt to use an engineering design process in other areas as well, including both math lessons and areas outside of math and science.

Table I: Teacher Use of Engineering in Their Classrooms
(Scale: 1 = Almost Always, 2 = Pretty often, 3 = Once in a while, 4 = Never)

	Pre		Follow-up		Statistics	
	Mean	SD	Mean	SD	t-test /probability	Effect size#
I use engineering examples in science lessons	3.17	.83	2.35	.78	4.23/.000	1.02
I use an engineering design process in science lessons	3.17	.94	2.26	.81	4.61/.000	.95
I describe engineering careers to my students	3.33	.82	2.54	.98	3.8/.000	.87
I use engineering examples in math lessons	3.5	.61	2.85	.88	3.32/.002	.86
I talk about the courses and skills needed to go into engineering	3.46	.833	2.75	1.07	3.33/.001	.74
I use engineering examples in subject areas other than math and science	3.4	.75	2.95	1.0	2.27/.018	.53
I use an engineering design process in subject areas other than math and science	3.45	.83	2.95	1.05	1.88/.036	.53
I use an engineering design process in math lessons	3.55	.70	3.15	.99	1.9/.036	.47

* In social sciences, an effect size greater than .5 is considered large, although some feel it is necessary for an effect size to be greater than .8 to be large.

These changes are particularly impressive since almost two thirds of the teachers (62.5%/15) implemented only one EiE unit during the year. The other teachers did two units (2), did three units (3), or did not answer the question (4).

After participating in EiE, teachers significantly increased their use of problem-solving strategies not explicitly related to engineering in their teaching.

Not only did teachers increase their use of engineering in their classrooms, but after participating in EiE, they significantly increased their use of four other problem-solving strategies and increased the already frequent degree to which they asked students what they know about the topic being covered, although the differences were not as large as those seen in Table I.

Table II: Changes in Teacher Instructional Pedagogy
(Scale: 1 = Almost Always, 2 = Pretty often, 3 = Once in a while, 4 = Never)

	Pre		**Follow-up**		**Statistics**	
	Mean	**SD**	**Mean**	**SD**	**t-test /probability**	**Effect size**
I ask students what they know related to the topic being covered	**1.62**	**.71**	**1.17**	**.38**	**2.88/.008**	**.8**
Students use things from everyday life in solving problems	**2.39**	**.66**	**2.0**	**.74**	**2.4/.025**	**.56**
Students work on problems for which there is no immediately obvious method of solution	**2.92**	**.58**	**2.54**	**.83**	**1.99/.06**	**.53**
Students explain how they solve complex problems	**2.7**	**.62**	**2.33**	**.76**	**3.19/.004**	**.53**
Students explain orally or in writing the rationale behind the problem solving strategies of other students	**3.04**	**1.0**	**2.62**	**.92**	**2.01/.06**	**.4**
Students work together in pairs or small groups	1.58	.58	1.46	.51	NS	
Students use calculators/computers	2.38	.65	2.17	.7	NS	
Students collect data or information to analyze	2.21	.78	2.08	.65	NS	
Students work on projects	2.17	.70	1.96	.75	NS	
Students discuss their completed homework	2.36	.85	2.05	.84	NS	
Students try to solve sample problems	1.91	.73	1.96	.71	NS	
Students explain orally or in writing their problem solving strategies	2.17	.70	2.12	.74	NS	
Students solve the same problem using more than one method	2.35	.78	2.13	.17	NS	
I use practical or story problems related to everyday life	2.04	.69	1.79	.88	NS	
I use the textbook	2.5	.88	2.62	1.01	NS	

Not surprisingly, most teachers came into EiE wanting to include more engineering in their classroom and, over the year, the numbers increased. Reasons for wanting to do more engineering changed to include more of a focus on problem-solving and on including more real life topics.

Almost three quarters of the teachers came to EiE (71%/17) wanting to include more engineering content in their classrooms, while the remaining teachers (29%/7) were unsure. By the end of

the year, 83% (20) still wanted to include more engineering content, two were unsure, and the remaining two did not. As indicated earlier, 20 teachers reported doing at least one EiE unit. In addition, by the end of the year, the number of teachers reporting using other kits related to engineering increased from 12% (3) to 29% (7), while the number saying that they did other unspecified engineering related activities decreased from 46% (11) to 33% (8).

Teachers were also asked why or why not they would like to include more engineering topics with their classes. Between their pre and follow up responses, the biggest changes were an increase in teachers' commenting on engineering's relationship to real life topics (from 0% to 17% (4)) and on engineering's promotion of thinking and problem-solving (from 4% (1) to 17% (4)). The decreases were related to teachers' mentioning of engineering as hands-on/experimenting/inquiry (from 17% (4) to 4% (1)) and to teachers' expressing concerns about their inexperience (from 12% (3) to 0%).

Table III: Teacher Reasons for Wanting/Not Wanting To Include More Engineering Topics in Their Classroom

	Pre	**Follow-Up**
Ties into other content areas	33%/6	17%/4
Promotes thinking and problem-solving	4%/1	17%/4
Relationship to real life topics	0%	17%/4
Kids like it	17%/4	12%/3
Time	4%/1	8%/2
Team building	0%	4%/1
Hands-on, experimenting, inquiry	17%/4	4%/1
Career focus	12%3	4%/1
New teacher/inexperience	12%/3	0%
National need	8%/2	4%/1
Relevance	4%/1	0%
Need to know more	4%/1	0%

Individual teacher comments included:

- The engineering design process promotes thinking and problem-solving and we do not have enough of those processes in students' everyday school experiences.
- The more you can tie in "real life" to learning, the better.
- At this point, I need to learn more about how I might use an engineering model.
- There is a big push on the standards – it's hard to do things that do not follow state guidelines.

After participating in EiE, the number of teachers including design, problem solving, and process/design process as part of their definitions of engineering increased dramatically.

As Table IV indicates, in both the pre and follow-up surveys, teachers incorporated a variety of elements into their definitions of engineering. However, after participating in EiE, teachers were much more apt to often include problem-solving, design, and design processes as elements of their definitions.

Table IV: Teacher Definitions of Engineering

	Pre	Follow-Up
Problem-solving	29%/7	67%/16
Design	38%/9	67%/16
Process/design process	4%/1	33%/8
Improve	17%/4	21%/5
Create	17%/4	21%/5
Tools/technologies	12%/3	21%/5
Make life better/easier	8%/2	21%/5
Science	17%/4	17%/4
Math	12%/3	12%/3
Product	4%/1	8%/2
Plan	17%/4	8%/2
Build	21/%/5	8%/2
Various fields of engineering mentioned	8%/2	0%
Test	8%/2	0%

Teachers were very satisfied with the EiE units.

As can be seen in Table V, teacher ratings of EiE were very positive with almost all teachers strongly agreeing that they would do the units again in their classes. The least positively rated items were related to logistics—clean-up and having enough time to do the activities. The other logistical area—ease of getting materials—was highly rated, but it must be remembered that EiE teachers received materials as part of their EiE participation.

Table V: Teacher Assessment of EiE Units*
(Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree)

I would do this unit again with my class	4.72
The directions were clear	4.50
The science connections were useful.	4.50
The materials were easy to get	4.38
Students were able to successfully complete the design challenge	4.30
The literacy connections were useful.	4.30
I have enough knowledge to do the lessons	4.30
I was comfortable leading the lessons	4.27
The storybook held students' interest	4.08
It was not difficult to keep students on task	3.98
Clean-up was not a problem	3.91
There was enough time to do the lessons	3.84

* Results are based on 16 ratings: 7 on the electrical engineering unit, 6 on bioengeering, and 3 on acoustical engineering.

Conclusions

EiE training and participation had a strong positive impact on these teachers' instructional behavior. Not only did teachers include more engineering examples, concepts, and career information in their classes, they also incorporated more problem-solving strategies in their science instruction, their math instruction, and other areas. Their increased interest in problem-solving can also be seen in changes in teachers' reasons for wanting to include more engineering in their classes and in their definitions of engineering.

Teachers were very positive in their ratings of the EiE units. They appeared not to have had any problems using the activities and have a great interest in doing the units again. Overall, EiE made a difference for these teachers.