

Engineering is Elementary: An Evaluation of Years 7 and 8 Field Testing

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Executive Summary

Engineering is Elementary (EiE) began curriculum development efforts in 2003. EiE has created 20 supplemental curriculum modules to teach elementary school children engineering in a hands-on manner, in the context of science (as taught by the most common hands-on science curricula). This report details evaluation findings (both formative and summative) for the field test (second draft) versions of the final 5 engineering units of 20 created by the EiE development team. Three units, *Cleaning Up an Oil Spill*, *Replicating an Artifact*, and *Designing Submersibles*, were created and piloted (first draft version) during the 2008-2009 school year, and field tested during the 2009-2010 school year. Two units, *Designing Knee Braces* and *Designing Lighting Systems*, were piloted during the 2009-2010 school year and field tested during the 2010-2011 school year.

This report details findings of formative and summative assessment for five *Engineering is Elementary* curricular units. The five units were early drafts, designed to teach elementary school students about engineering and technology while reinforcing science concepts. For each of the five field test units we have evaluated in this report, surveys of implementing teachers revealed that teachers, overall, found the units worthwhile and indicated that they would teach them again in the future. Teachers most often commented on (1) students' enjoyment of the EiE unit and their motivation to participate, (2) the high quality of activities and materials, and (3) the value of opportunities designed into the EiE unit helping for students to learn science and other STEM content.

In our summative assessment, for all five field units we have found that students participating in EiE had higher scores on the post-assessment than they did on the pre-assessment; improvements were significantly large, and as the confidence intervals did not include zero, it is unlikely that improvements are due to chance. In many cases, demographic variables including whether a student has limited English proficiency (LEP), received free or reduced-price lunch (FRL), has an Individualized Education Program (IEP), or is from an underrepresented minority group (Black or Hispanic) were associated with weaker though still significant levels of improvement from the pre- to the post-assessments than that of other students. For a few scales, the performance of underrepresented minorities was indistinguishable from zero.

Formative Assessment. Formative assessment for the field test (second draft) versions of the EiE units was mostly comprised of written feedback from field test teachers. Teachers consistently reported high satisfaction with the units (see Table 1) with the mean "likelihood to teach again" rating ranging from 5.5 to 6.3 out of 7 ("Very Likely") across all five units. All lessons but 2 were rated 5.8 out of 7 or higher; *Designing Submersibles* Lesson 1 was rated 5.6, and *Designing Lighting Systems* Lesson 3 was rated 5.1—this lesson frequently suffered from failure of materials.

Table 1. Summary of Mean Lesson Ratings and Likelihood to Teach Again on a Scale of 1-7

	CO	RA	SB	KB	LS
Rating of Lesson 1	6.1	5.9	5.6	6.3	5.8
Rating of Lesson 2	6.0	6.3	5.8	6.2	6.0
Rating of Lesson 3	6.1	6.3	6.2	6.3	5.1
Rating of Lesson 4	6.6	6.2	6.3	6.5	6.1
Likelihood to Teach the Unit Again	6.3	5.9	5.9	6.2	5.5

The most common positive feedback for each unit as a whole, as well as for each of the individual lessons, was that doing EiE was fun, engaging, and/or motivating for students. The percentage of teachers making this comment in response to open-ended questions ranged from 18% to 61% across all units and lessons. Teachers also consistently praised the quality of materials and activities: from 5% to 60% of all teacher responses were coded for praise of this kind. All units, and all lessons 2 and 3, provided good opportunities for students to engage in science and other STEM content, according to teachers: 46% to 64% of teachers made this comment when asked about the benefits of the units they taught. Also, for all units, teachers consistently commented that their students practiced discussion, communication, and/or teamwork, which they saw as giving important opportunities to improve their students' skills. Sixteen percent to 25% of teachers made this comment.

Some teachers provided negative feedback when asked to explain their rating of a lesson. We consistently found that a subset of teachers found Lesson 4 (the design challenge) to be difficult or confusing. The percentage of teachers making this comment ranged from 7% to 18%. Another common complaint was that lessons took too much time, though not all unit / lessons received this complaint. Finally, Lesson 3 and Lesson 4 was commonly criticized for being difficult to implement. Zero percent to 28% of teachers made this complaint about Lessons 3 and 4.

Other than science, many teachers mentioned content areas that were supported or reinforced by the EiE units they field tested. The most common of these was language arts, mentioned by 50% to 79% of teachers across units. Mathematics was mentioned by 20% to 33% of teachers across units.

Summative Assessment. For all scales for all five units, we found that students overall improved from the pre-test to the post-test. This improvement was always highly significant ($p < .001$), and correspondingly, the 95% confidence intervals always excluded zero. This indicates that students learned about engineering and science while they were participating in EiE. Though we cannot say that EiE caused these outcomes, the evidence is promising for the efficacy of EiE. Not all demographic groups improved equally, however. Demographic groups which improved significantly less (or more) than the reference group as defined by each model are detailed in the main report.

Recommendations. Despite the evaluation being conducted on “draft” versions of the EiE units, the five units reviewed show promise as means for helping students learn about science and engineering—both content and skills such as discussion, teamwork, and problem solving. Teachers consistently reported that their students were engaged and motivated to participate in EiE lessons and design challenges. Though some demographic groups improved less than others, still outcomes were consistently positive, with only a few instances where improvements could not be detected.

Because no control or comparison group was detected, we cannot say that EiE is the cause of the score changes we measured. However, our findings across teacher qualitative data and student quantitative results are strong and consistent enough to be encouraging about the promise of EiE for engaging students and helping them to learn science and engineering.