Evaluating the Efficacy of Engineering is Elementary® for Student Learning of Engineering and Science Concepts

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Abstract
Using the data from a randomized-controlled trial (RCT), we evaluated the efficacy of Engineering is Elementary® (EiE), an elementary engineering curriculum intervention grounded on the principles of inquiry and project-based learning. We assessed the intervention’s effectiveness using intent-to-treat analyses. The results showed that the intervention curriculum was particularly effective for improving student learning of science concepts required to understand the problems and processes of engineering.

Method
Recruitment & Randomization
- Contacted principals of schools in MA, MD, & NC to recruit
- Selected 359 teachers from 244 schools out of 613 eligible teachers
- Randomly assigned schools to EiE or control (E4C), and then teachers in EiE to one of 4 EiE units and those in E4C to one of 4 comparison units
- Randomly assigned half of 252 volunteer teachers to implement an extra unit (civil engineering) as a second dose

Teacher Training
Teachers attended a 3-day professional development workshop in the summer and a 1-day follow-up session in the spring. Training included:
- introduction to engineering & hands-on sessions on the assigned unit
- modeling curriculum-specific pedagogy, class management, & activities
- preparation for data collection by reviewing protocols & requirements

Curriculum Implementation & Data Collection
- Student pretest and demographic data were collected prior to intervention
- Teachers then implemented their science curricula and engineering unit, each with approximately 10 hrs of content over 8-10 lessons
- Upon completion, teachers collected posttest data from students
- All unit-specific engineering & science assessment instruments were developed by the project team and tested for validity and reliability

Attrition & Final Analytic Samples
- 5% & 15% of school attrition during 1st and 2nd year, respectively
- No different attrition rate b/w EiE and E4 schools; no significant difference of any attrition rate across school characteristics
- See table below for final analytic sample size for each engineering unit and graphs below for characteristics of all schools in the samples

Analysis & Result
Baseline Equivalence
- Examined the baseline equivalence of the treatment and control groups at the school, classroom, and student levels to determine whether randomization was successful using independent sample t-tests and chi-square tests
- Found little significant difference in baseline demographic characteristics and pretest scores b/w the two groups

Impact of EiE Intervention
- Employed 3-level hierarchical linear modeling to conduct intent-to-treat analyses of the impact of EiE
- Adjusted for student gender, race, pretest score, and free/reduced lunch status; classroom grade level, cohort and an extra unit implementation; and school location, school average pretest score
- Table below presents the results of the analyses

Unit | Assessment Outcome | Estimate (SE) | Effect Size
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Electrical | Energy | 0.13 (0.17) | 0.07
Electricity | 0.12 (0.19) | -0.07
Pollution | 0.05 (0.12) | 0.03
Environmental | Read foodwebs | 0.26 (0.11) | 0.17
Analyze foodwebs | 0.19 (0.11) | 0.10
Geotechnical | Foundation | 0.26 (0.34) | 0.11
Landforms | 0.63 (0.22) | 0.22
Plan a | 0.01 (0.07) | 0.01
Package | Package Design | 0.33 (0.19) | 0.14
Plant Structures | 0.37 (0.23) | 0.26
Needs for Plants | 0.18 (0.08) | 0.18

Note: * p < .05, † p < .10, * superscript indicates engineering domain and † superscript indicates science domain

Next Steps
- Conduct moderating analyses to examine if EiE effects would differ depending on student- and class-level characteristics
- Conduct treatment-on-the-treated analysis to examine the mediating role of fidelity of implementation (FOI)

Conclusion
Findings & Discussion
- Found significant or marginally significant effects of EiE on 5 out of 7 science assessment outcomes, and 1 of 5 engineering assessment outcomes
- Given the short period of curriculum implementation, the findings provide good evidence for the efficacy of the EiE intervention, particularly for science
- Both treatments addressed the same engineering objectives using different pedagogies, so lack of significance of factual engineering outcomes unsurprising
- The EiE curriculum was designed to apply science concepts. Both groups learned the same science content but those using EiE had improved science outcomes.

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