JRST
Journal of Research in Science Teaching
Research Brief
VOL. 60, NO. 2, PP.330-356 (2023)

Effect of design-based learning on achievement in K-12 education: A meta-analysis

Ibrahim Delen & Sedat Sen

Overview: The goal of this study was to conduct a meta-analysis that would provide a comprehensive picture of how design-based learning is related to student achievement in different disciplines (e.g., science, mathematics, and technology) and by exploring relationships with variables such as school level and forms of content support.
Audience: Science communication practitioners; Informal learning educators; Researchers; Evaluators

Key Points

- Design-based learning had a positive and large effect (g=0.602) on achievement in K-12 education.
- The effect size for science (g=0.703) was higher than mathematics (g=0.418) education.
- Studies that had control groups in the same school had statistically significantly higher effect sizes than those that relied on control groups in different schools.
- The effect of design-based learning on achievement showed statistically significant differences among different countries.
- Design-based learning activities supports student achievement after the intervention, but how students transfer their content gains in other situations requires additional research.

INTRODUCTION Design-based learning (DBL) offers opportunities to support students' content understanding. An important idea of DBL and DBL frameworks is problem solving and DBL also supports inquiry through design. Previous meta-analysis studies reported large effect size when reviewing problem-based learning and inquiry learning. Our study added another dimension to these meta-analysis studies by offering a comprehensive picture that will portray how DBL is related to achievement in different disciplines. In addition, this study explored the moderators influencing achievement in DBL for K-12 education.

FINDINGS After investigating content related gains in our meta-analysis on 37 individual articles with 52 effect sizes [science (60%), math (29%), technology/STEM (7%), social studies (2%) and language (2%)], we found that DBL had a positive and large effect (g= .602) on achievement in K-12 education, and the effect size for science ($\bar{g}$=0.703) was higher than mathematics (g= 0.418) education. Studies that had control groups in the same school ($\bar{g}$=0.703) had statistically significantly higher effect sizes compared to studies that included control groups from different schools (g= 0.447). Studies with random assignment (g= 0.258) had statistically significantly smaller effect sizes compared to studies with non-random assignment (g= 0.623). In addition, the effect of DBL on achievement showed statistically significant differences among different countries. The remaining moderators (school level, content support, measurement type, and experimental design) did not show statistically significant differences in terms of the effect of design-based learning on student achievement.

TAKEAWAYS One possible explanation for the larger effect size is the iterative nature of the design process. It's also worth noting that design is more than a practice; it also entails students' sensemaking to integrate crosscutting concepts and disciplinary core ideas. When considering the strong emphasis on science education in different design-based learning related frameworks and STEM (Science, Engineering, Technology, and Mathematics) education studies, this cumulative understanding could play an important role in the difference between science and mathematics. In comparison to other countries such as the United States, Taiwan, Spain, and China, studies from the Netherlands and Turkey had much bigger effect sizes. Intervention durations in these studies ranged from two to 16 weeks (mean 5.79 weeks). A total of 65% of the studies selected control groups from the same school, whereas 35% used control groups in different schools. Content related support for designing products was provided in 34 studies (67%) while no content support was offered in the rest of the studies (33%). Our results may provide evidence that supporting design-based learning is instrumental for transferring student content learning when content support is missing. These patterns and the long-term impacts on transfer of design-based learning needs to be explored further.

Effect of Design Based Learning on Achievement in K-12 Education: A Meta-Analysis