RESEARCH BRIEF

Project-Based Learning Leads to Gains in Science and Other Subjects in Middle School and Benefits All Learners

Introduction

Growing evidence shows that rigorous project-based learning (PBL) benefits students. However, there is a need for further research examining the impact of project-based learning on science learning at the middle school level, particularly in racially and ethnically diverse schools that also serve low-income students and English language learners.

To address that, a team of researchers and teachers designed the Learning Through Performance (LTP) in Middle School Mathematics and Science project. They developed, piloted, and researched the efficacy of a sixth-grade project-based learning science course and professional learning, aligning the curriculum with the Next Generation Science Standards (NGSS).

The researchers examined the impact of the PBL curriculum on student engagement and science achievement. The results showed the curriculum had positive effects on both measures. In addition, LTP students outperformed peers on standardized tests in mathematics and English language arts. And LTP students classified as English language learners outperformed peers on a standardized English proficiency test. The findings from the three-year research study—funded by Lucas Education Research, a division of the George Lucas Educational Foundation—present strong evidence that all students experience multiple benefits from learning science through hands-on, rigorous project-based learning.

About the study

The researchers investigated how a science course designed with a project-based learning approach and performance-based assessments impacted student engagement and academic achievement. Researchers also examined the impact of professional learning that incorporated opportunities for teachers to further develop and refine the curriculum.

Researchers used state test scores and other measures to examine the effects of students' participation in LTP on their achievement during Years 2 and 3 of the study. The state tests included the Smarter Balanced assessments in mathematics and English language arts (ELA) and the California English Language Development Test (CELDT).

A matched comparison study design used advanced statistical models to develop a comparison group of students who were matched according to multiple variables, such as race, ethnicity, gender, income status, and prior academic performance. This matching process created a comparable group of students who did not have access to

the LTP curriculum. For a comprehensive review of the study methodology and analytic approach, see the researchers' report.

Results

The research showed that the use of the LTP science curriculum and aligned professional learning led to increased student engagement and significant gains in performance on all assessments across both Year 2 and Year 3 of the study. Specifically, the performance of students in LTP classrooms ranged from 8 to 28 percentage points better than students in the comparison group, depending on the assessment. The many components of the LTP program—from a teacher-researcher design team to strategies that foster strong group work to language and literacy scaffolds—resulted in implementation that led to deep engagement and academic growth.

Researchers conducted the study in high-poverty, racially diverse schools. As a result, the study provides important evidence about the effects of PBL on traditionally underserved students, including English language learners, who are more likely than other students to receive science instruction focused on basic skills rather than emphasizing higher-order thinking and discussion skills as in rigorous PBL science instruction.

About Learning Through Performance

A team from the Stanford Center for Assessment, Learning, and Equity, in collaboration with a group of middle school teachers, developed the yearlong, project-based science curriculum in alignment with NGSS. The researcher-developed, sixth-grade Learning Through Performance curriculum is openly available.

Throughout the school year, students develop scientific explanations to answer the overarching question, "How do humans influence the world, and how does the world influence humans?"

As students investigate, they learn about scientific phenomena and issues related to this driving question. Each of the five units in the curriculum centers on authentic projects and includes rigorous performance-based assessments and strategies for group work. The units are described below:

- **Orientation to Group Work:** How do we work productively in a group?
- **Energy:** How do we use and control thermal energy in a system?
- **Cells and Body Systems:** How do body systems interact with one another to communicate and collaborate?
- **Variation and Heredity:** How do the environment and genetics affect who we are and how we are similar or different?
- **Climate Change:** How do we know human activity is influencing climate, and what can we do about it?

Researcher-developed performance-based assessments allow students to demonstrate their knowledge and include both group-worthy and individual assessments. For example, in one unit on energy, students work in groups to design a device that controls thermal energy transfer (for example, keeping something warm). As they add to their ideas for the device, they demonstrate their learning progress. As a final product, students create individual patent applications for their group's device to connect what they have learned to the project.

Teaching and assignment quality
LTP teachers improved at facilitating group work to support student participation in the learning tasks embedded in each unit and in end-of-unit culminating group projects. Results also showed that LTP teachers (1) increased their use of activities that involved real-world, hands-on applications of science; (2) increased their use of language-rich assignments and discussion strategies that required students to explain their understanding of the content; and (3) grew in their use of performance assessment.

Student engagement
Student engagement significantly improved over the course of the study, particularly from Year 2 to Year 3. In Year 2, LTP students performed significantly better than a comparison group on a pre- and post-assessment that measured engagement in science practices. This increased engagement was also evident in LTP teacher reports as compared with non-LTP teacher reports of student engagement. In addition, LTP students reported that their classroom assignments were more interesting, challenging, worthwhile, and enjoyable as compared with reports from the comparison group.

LTP science assessment
In Year 2, 139 LTP students significantly outperformed 145 students in a comparison group by 11 percentage points ($p < .05$) on a science assessment developed as a measure of students' proficiencies with NGSS practices. In Year 3, LTP students also made significant learning gains on the same science assessment administered before and after the course (*ES* = 0.47, $p < .001$). Note that *p* stands for "probability." A *p* value helps to determine the significance of the results. Additionally, "effect size," or *ES*, is a simple way of quantifying the difference between groups.

Smarter Balanced assessments in mathematics and English language arts
LTP students outperformed comparison students on state standardized tests in mathematics and English language arts. On average, LTP students outperformed their peers on the mathematics test by 12 percentage points in Year 2 and by 18 percentage points in Year 3. LTP students outperformed their peers on the ELA assessment by 8 percentage points in Year 2 and by 10 percentage points in Year 3, on average.

California English Language Development Test
LTP students classified as English language learners outperformed matched students on the CELDT. California used the assessment to measure students' skills in listening, speaking, reading, and writing in English during the time of this study. Researchers reported positive and meaningful effects for two years in a row. LTP English learners' performance on CELDT was significantly greater than the comparison English learners' performance by an average of 8 percentage points in Year 2 and an average of 28 percentage points in Year 3.

All the analyses above revealed statistically significant effects. Table 1 provides the effect sizes and *p* values for the Smarter Balanced assessments and CELDT for each year.

Table 1. Impact of Participation in LTP on Student Performance (LTP vs. Comparison)

	Year 2 (2014–15)		Year 3 (2015–16)	
Assessment	Effect Size	Sample	Effect Size	Sample
Smarter Balanced ELA	0.10**	328 LTP/9,675 comparison	0.08**	347 LTP/8,098 comparison
Smarter Balanced Math	0.13**		0.19*	
CELDT	0.72**	33 LTP/2,023 comparison	0.23**	57 LTP/1,745 comparison

*$p < .005$ **$p < .001$

Discussion

Overall, the research findings validate the idea that rigorous PBL course work and aligned assessments and professional learning can support teachers and students. The study's finding that LTP teachers improved at fostering positive group work is a significant contribution to the research literature. Educators view productive student collaboration as an important goal but one that is hard to achieve. This study offers examples of practices that facilitate a language-rich and active learning environment, the kind that encourages positive group work. The curriculum design team used an approach known as complex instruction, which likely also contributed to the positive findings related to group work. This approach involves assigning student roles to promote active learning and equitable participation, offering open-ended activities, and empowering students to lead their learning with teacher support.

STUDY DETAILS

This study offers examples of practices that facilitate a language-rich and active learning environment, the kind that encourages positive group work.

From an equity standpoint, the design team ensured that content was accessible for all students, including English language learners, which likely contributed to gains for that subgroup. Some of the design features of the curriculum that support English language learners include language-specific objectives, balancing writing and discussion, and other targeted strategies to foster language development.

Conclusion

Over a three-year period, the Learning Through Performance science curriculum fueled gains in student engagement and learning outcomes. LTP science teachers reported that students appeared to be more interested, motivated, and engaged in learning science and engineering practices, and they seemed more interactive during group work than students not participating in the curriculum. Participating students viewed their assignments favorably.

Student performance on state assessments supported the above findings and revealed statistically significant effects across all measures and for both years of the study, with changes in performance ranging from 8 to 28 percentile points better for students in the LTP classrooms. It is notable that LTP—a PBL approach to science that also attends to equity, language, and literacy—resulted in significant improvements in state measures of mathematics and ELA. Importantly, the equitable and language-rich approach to science instruction also resulted in robust improvements in performance on the state language-proficiency test for English language learners.

This study provides important evidence that when underserved students, including English language learners, engage in authentic, real-world science instruction, significant learning across multiple content areas occurs. With that in mind, policy makers and education leaders should consider project-based learning as a lever for increasing and improving student engagement, learning, and equity outcomes.

ACKNOWLEDGMENTS

This brief is based on the research paper "Project-Based Learning as a Lever for Engaging the Next Generation Science Standards" written by Rebecca R. Deutscher, Nicole C. Holthuis, Saúl I. Maldonado, Raymond L. Pecheone, Susan E. Schultz, and Ruth Chung Wei. Project leadership included Linda Darling-Hammond (principal investigator), with Susan E. Schultz and Nicole C. Holthuis (curriculum design team leads) and Rebecca R. Deutscher (project lead).

Images courtesy of Edutopia