Sonoma State University

Learning by Making (LbyM)

DID LBYM IMPACT HIGH SCHOOL STUDENTS' MATH AND SCIENCE PERFORMANCE?

Project Overview

THE PROBLEM: What Challenge Did the Program Try to Address?

As of 2011, just 22% of Mendocino County, California residents had earned a bachelor's degree, versus a statewide average of 30%. In addition, as of 2012, only about 26% of county high school students graduated with courses required to enroll in California public universities, as compared to an average of 38% of students statewide. In this context, Sonoma State University (SSU) applied for and received an i3 development grant[1] (2014–2018) to implement and evaluate Learning by Making: STEM Success for Rural Schools[2] in six high schools in Mendocino County, California.

THE PROJECT: What Strategies Did the Program Employ?

Sonoma State's Learning by Making (LbyM) program developed an innovative high school STEM curriculum that used computational thinking to focus on real world problem solving. Specifically, the program went beyond traditional project-based learning approaches to join mathematical skill building and computational thinking based in the Logo programming language. It then applied this fusion to real-world science problems that teachers and students worked to solve together, a learning approach known as "constructionism." The LbyM impact evaluation used a quasi-experimental design to compare a set of students who were recruited to enroll in LbyM STEM classes to a comparison group of students who were enrolled in other science or math classes.

[1] Development grants provide funding to support the development or testing of novel or substantially more effective practices that address widely shared education challenges. All i3 grantees are required to conduct rigorous evaluations of their projects. The quality of evidence required to demonstrate a project's effectiveness depends on a project's level of scale or grant type.

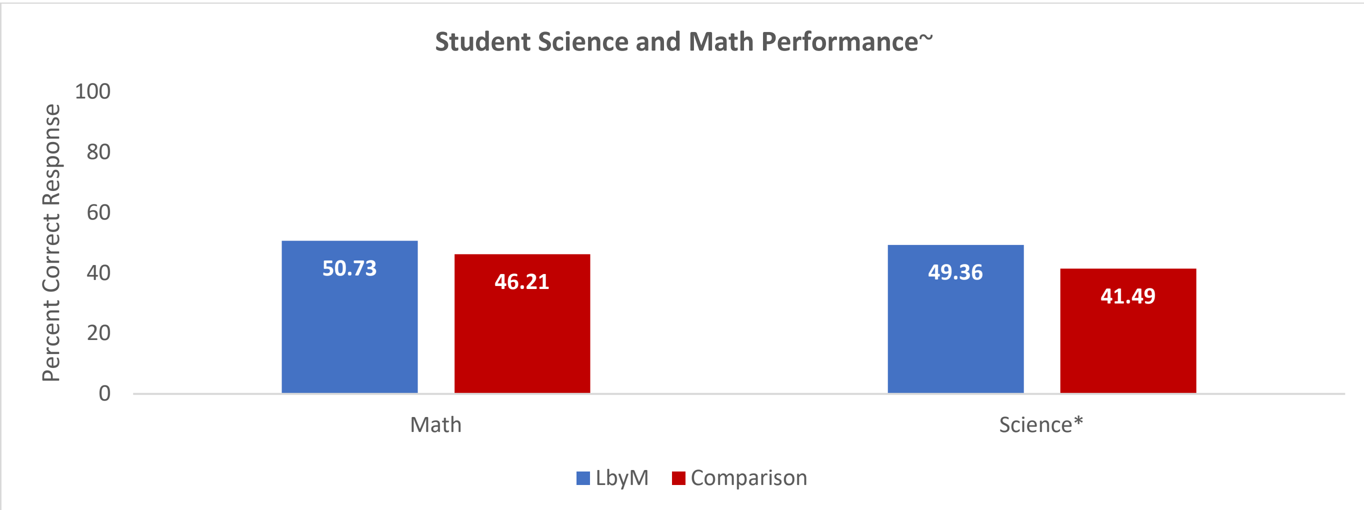
[2] Sonoma State University received an i3 development grant supported by the U.S. Department of Education's Investing in Innovation program through Grant Number U411C130090.

THE LEARNING BY MAKING MODEL

- **LbyM Curriculum.** The LbyM curriculum comprised Disciplinary Core Ideas (DCIs) in Earth Science, Biology, Chemistry, and Physics as described in the Next Generation Science Standards (NGSS). In particular, the curriculum emphasized the NGSS concepts of Cause and Effect, Systems and System Models, and Stability and Change. Through the lessons in the curriculum, the goal was to have students develop and use models, construct explanations and arguments from experimental evidence, and report and communicate their results to their peers and instructors. The curriculum also used the Logo programming language to foster computational thinking. Students designed investigations in which they used Logo to write code in order to read and transfer data from sensors. They also built on basic coding to perform experiments, create simulations, and explore models.
- **Professional Development (PD).** The program provided teachers with ongoing PD that emphasized technology and engineering capabilities, including computer coding and circuitry. Teacher training also included instructional methods focused on having students learn through inquiry, data collection, and experimental design. Teachers participated in a five-day summer training institute, five one-day follow up sessions during the year, and had access to an online platform with teaching resources. SSU staff were also available to provide support during classroom implementation.

Summary of Results

DID LBYM IMPACT HIGH SCHOOL STUDENTS' MATH AND SCIENCE PERFORMANCE?



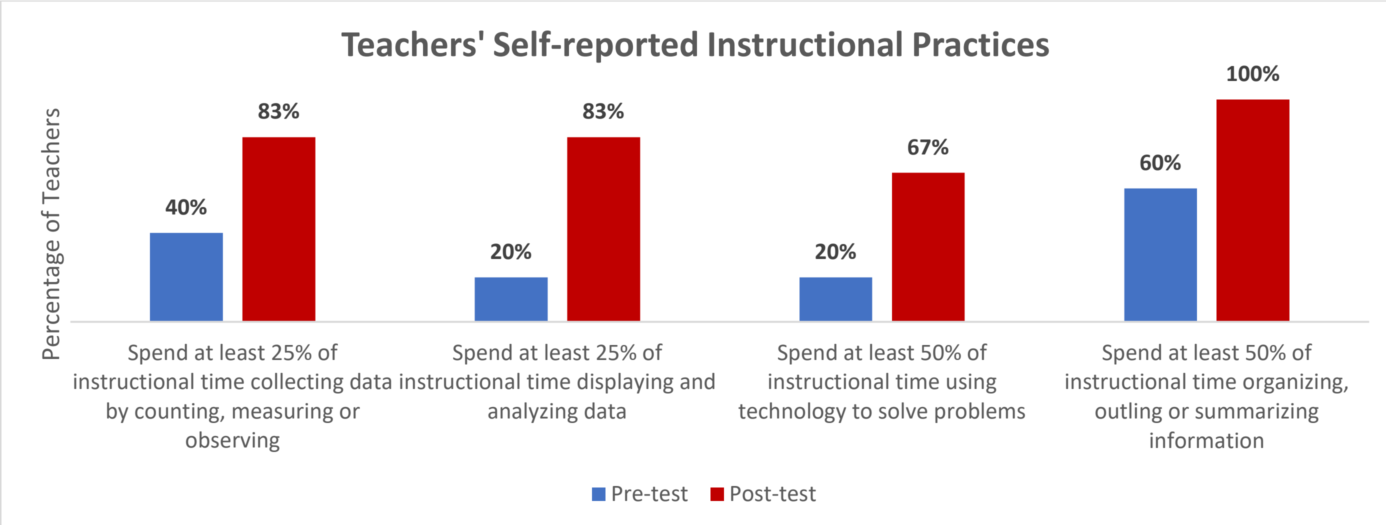
*Results are statistically significant.
~ Science and math tests were comprised of items selected from the Certica Formative Assessment Item Bank. The Item Bank is a repository of mathematics items aligned to Common Core Standards in Mathematics and to Next Generation Science Standards. The selected assessment items focus on math and science topic areas covered in the LbyM curriculum.

- **SCIENCE PERFORMANCE.** Students in LbyM courses had greater gains than their comparison peers in science content knowledge. The difference in gains was statistically significant. On average, students in LbyM scored seven points better on the science assessment than those in the comparison group, an effect size of 0.34.
- **MATH PERFORMANCE.** There was no statistically significant difference in math gains between LbyM students and their peers in the comparison group.

Please see Appendices B and C for information about the evaluation's design and the quality of the evidence, respectively.

SECONDARY FINDINGS

The evaluation also looked at exploratory outcomes regarding teacher instructional practices as well as student attitudes towards STEM fields. Surveys indicated that the most observable changes for teachers occurred in supporting students' work with data and in their own technological abilities. Student attitudes did not change in major ways.



- **Teaching Practices: Working with Data.** Compared to before the intervention, the percentage of teachers who reported spending at least a quarter of their instructional time to collecting data increased by 43%. The percentage who reported spending the same proportion of instructional time on displaying and analyzing data went up by 63%. The proportion of teachers who devoted half of their instructional time to using technology increased by 47%, while the percentage devoting the same amount of time to organizing, outlining, or summarizing information went up by 40%.
- **Teaching Practices: Technological Competencies.** The percentage of teachers who agreed or strongly agreed that they knew how to perform or carry out different technological skills rose across a number of different areas, with positive responses increasing by 40-60% across competencies.
- **Student Attitudes.** There were no significant changes in student attitudes toward math, science, engineering, or 21st Century Skills. In addition, following implementation, the evaluators found no statistically significant difference between LbyM and comparison group students' interest in pursuing a career across several different STEM fields.

OTHER CONSIDERATIONS

The study reported on the degree of implementation of the core program components, some challenges to implementation, and some qualitative assessments of student engagement with the curriculum.

- **IMPLEMENTATION: PROFESSIONAL DEVELOPMENT.** The PD trainings had consistently high attendance. During the 2016-2017 Summer Institute, teachers had a 92% attendance rate on four out of five days of the week. The follow up PD training sessions in October, December, and March had 100% teacher attendance, while the January and April sessions had 92% and 83% attendance, respectively.
- **IMPLEMENTATION: CHALLENGES.** The biggest challenges to implementation were student absenteeism and the time required to teach computer coding. Several teachers had major issues with student attendance, particularly in smaller schools. Absences were especially problematic for the program because there were no structures or materials in place for students to make up the work they missed. In addition, since many students had never worked with computer code, teaching them to code took a longer time and more class sessions than expected.
- **INQUIRY-BASED LEARNING.** Focus groups and interviews with teachers revealed that students responded positively to the inquiry-based elements of the curriculum, recognizing the relevance of the tasks and investigations for their lives. This observation supports prior research on rural education showing that student engagement, motivation, and learning is enhanced when science instruction incorporates local knowledge.
- **IMPLEMENTATION: LBYM CURRICULUM.** All teachers finished the 2016-2017 year with moderate fidelity to curriculum dosage. Progressing through the six units in the curriculum, four classes got close to the end of the fourth unit, while two other classes reached the beginning of the sixth unit. At times teachers skipped lessons in the units or taught them in a different order depending on time constraints and the perceived relevance of the lessons for their students. Most teachers also reported that they modified the lessons in the units. Their main reasons for doing so were that they felt they needed to provide background knowledge in preparation for upcoming lessons and that they needed to give students opportunities to practice the skills they were learning.
- **STUDENT ENGAGEMENT.** Data from observations, teacher interviews, teacher focus groups, and implementation logs demonstrated high levels of student engagement and greater student stamina for problem solving and overcoming unfamiliar challenges in the classroom.

- **COMPUTATIONAL THINKING.** Students and teachers both reacted enthusiastically to the computational thinking components of the LbyM curriculum. Teachers felt that students were motivated by the coding lessons and that they often learned the coding tasks more quickly than the teachers. This supports prior research suggesting that STEM curricula incorporating computational thinking can promote learning in rural schools. Accordingly, the evaluators noted that future research on the LbyM curriculum should focus on the impact of computational thinking on learning outcomes.

For More Information

Evaluation Reports
Final Evaluation Report (WestEd, November 2018)[3]

[3] The information and data for this result summary was collected from the most recent report as of 02/11/2020: WestEd (2018). *Evaluation of Learning by Making i3 Project: STEM Success for Rural Schools*. Retrieved from https://files.eric.ed.gov/fulltext/ED594016.pdf

Appendix A: Students Served by the Project[4]

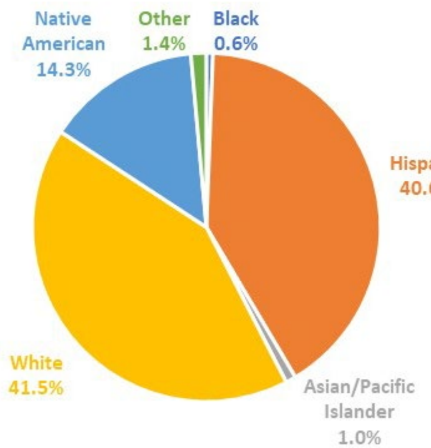
GRADE(S)

PK	K	1	2	3	4	5	6	7	8	9	10	11	12

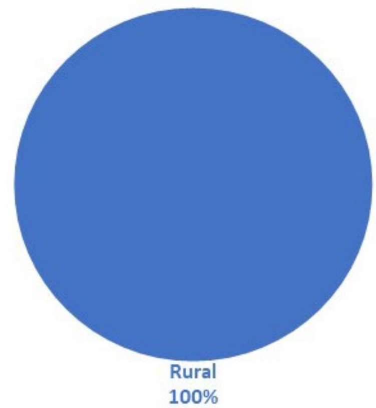
GENDER

Not Reported

RACE/ETHNICITY[5]



COMMUNITY



HIGH-NEED STUDENTS[i6]

Free/Reduced-Price Lunch	English Learner	Students with Disabilities
60.5%	12.9%	N/A

[4]These data reflect the entire student population served by the intervention, not just the evaluation sample used in the impact study.
[5] The race/ethnicity pie chart is based on average figures across the six participating high schools.
[6] The numbers in this table are averages across the six participating high schools.

Appendix B: Impact Evaluation Methodology[7]

RESEARCH DESIGN:

Design:	Quasi-Experimental Design
Approach:	▪ The study used a quasi-experimental design to compare high school student outcomes in math and science, recruiting both intervention and comparison group students from the same set of six high schools, which introduced LbyM classes. The intervention and comparison groups were equivalent at baseline on the science assessment; the baseline difference between the groups on the math assessment was statistically adjustable.
Study Length:	One year

DATA COLLECTION AND ANALYSIS

Study Setting:	Six High Schools in Mendocino County, California
Final Sample Sizes:	▪ *Intervention Group:* 52 students enrolled in LbyM STEM classes ▪ *Comparison Group:* 98 students enrolled in non-LbyM science or math classes
Intervention Group Characteristics:	▪ Not reported.
Comparison Group Characteristics:	▪ Not reported.
Data Sources:	▪ Student Assessments ▪ Surveys: Students and teachers
Key Measures:	▪ Math Achievement (Certica Formative Assessment Items: Linear and Non-Linear Equations & Research and Data Representation) ▪ Science Achievement (Certica Formative Assessment Items: Energy; Atmosphere & Weather; Heat) ▪ Student attitudes (Survey: Interest in STEM and STEM Careers) ▪ Teacher practices (Survey: Instruction and competencies)

[7] These data reflect only the evaluation sample in the impact study, not the entire population served.

Appendix C: Quality of the Evidence

WHAT WORKS CLEARINGHOUSE REVIEW[8]

STUDY	RATING
Not reviewed as of 02/11/2020	N/A

EVIDENCE FOR ESSA REVIEW[9]

STUDY	RATING
Not reviewed as of 02/11/2020	N/A

NATIONAL CENTER ON INTENSIVE INTERVENTIONS REVIEW[10]

STUDY	RATING
Not reviewed as of 02/11/2020	N/A

[8] https://ies.ed.gov/ncee/wwc/FWW
[9] https://www.evidenceforessa.org/
[10] https://intensiveintervention.org/

*The **Investing in Innovation Fund (i3)**, established under section 14007 of the American Recovery and Reinvestment Act of 2009, is a Federal discretionary grant program at the U.S. Department of Education within the Office of Elementary and Secondary Education (OESE). i3 grants help schools and local education agencies work in partnership with the private sector and the philanthropic community to develop and expand innovative practices that improve student achievement or student growth, close achievement gaps, decrease dropout rates, increase high school graduation rates, and/or increase college enrollment and completion rates for high-need students.*

This summary was prepared by the Education Innovation and Research (EIR) Program Dissemination Project. The project is conducted by the Manhattan Strategy Group, in partnership with Westat and EdScale, with funding from the U.S. Department of Education, Office of Elementary and Secondary Education, under Contract No. ED-ESE-15-A-0012/0004. The evaluation results presented herein do not necessarily represent the positions or policies of the U.S. Department of Education, and no official endorsement by the U.S. Department of Education should be inferred.

[i] "High-need student" refers to a student at risk of academic failure or otherwise in need of special assistance and support, such as students who are living in poverty, attend high-minority schools, are far below grade level, who have left school before receiving a regular high school diploma, at risk of not graduating with a diploma on time, who are homeless, in foster care, have been incarcerated, have disabilities, or who are English learners. For more information see: Applications for New Awards; Investing in Innovation Fund-Development Grants, 81 FR 24070 (April 25, 2016).