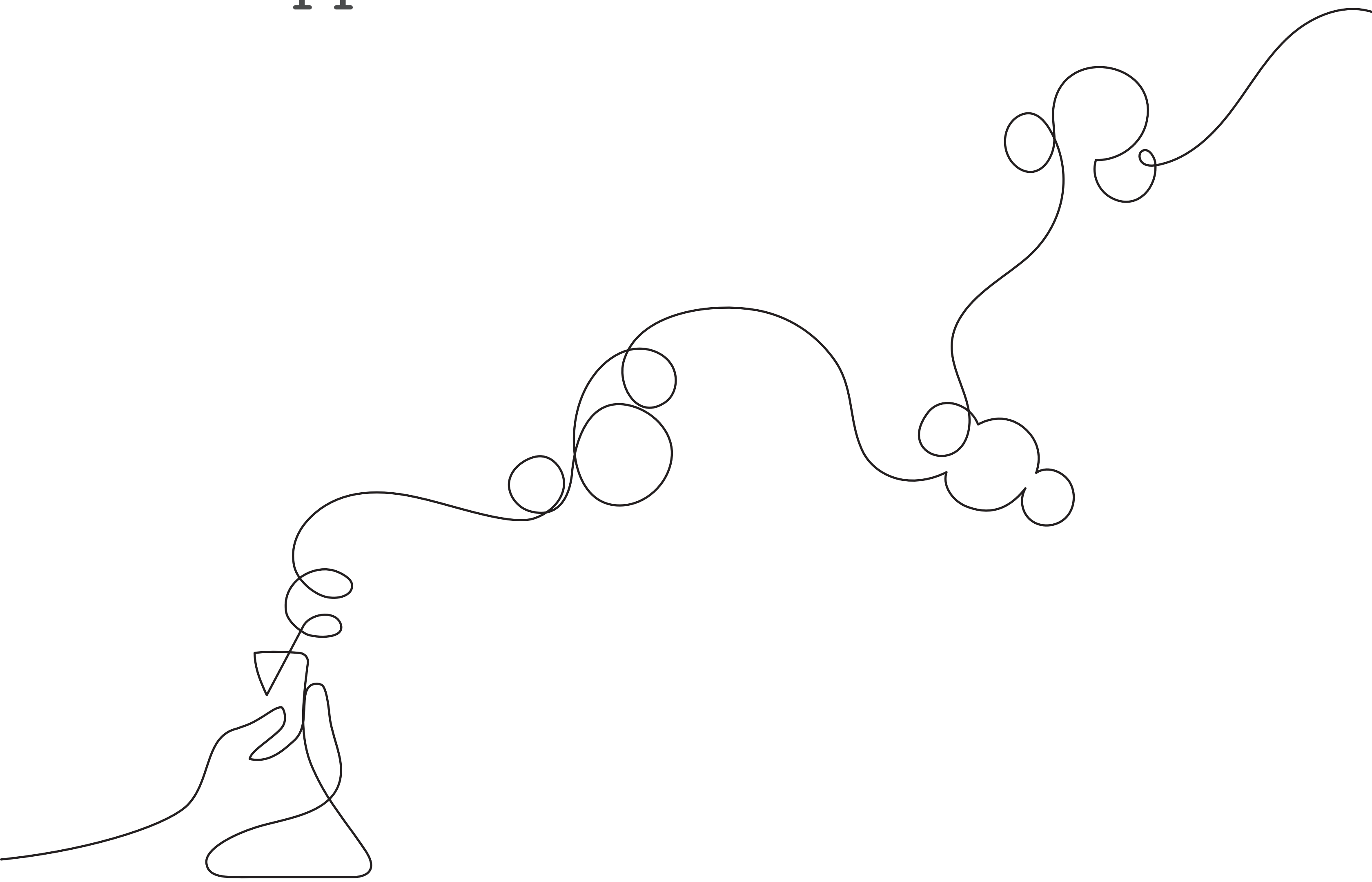
Amplify Science

The research behind the approach



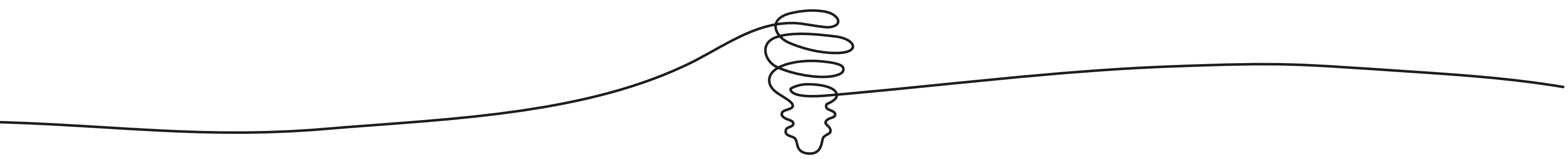


Table of Contents

Introduction

Amplify Science is a brand-new K–8 science curriculum designed to meet 100% of the Next Generation Science Standards (NGSS). It serves as a comprehensive curriculum complete with: detailed lesson plans, hands-on activities and materials, scientific texts, robust digital simulations, physical and digital models, opportunities for engaging student discussions, media, embedded formative and summative assessments, and a variety of effective teacher supports and options for professional development. Through investigations of scientific phenomena and real-world problems, students using Amplify Science learn to think, read, write, and argue like real scientists and engineers, thereby gaining a better understanding of the natural and designed worlds.

Amplify Science is the result of seven years of intense research and development, including:

- Intensive work in classrooms in 2010–2013 to develop and evolve instructional models based on the latest research and the consensus report, *A Framework for K–12 Science Education (National Research Council, 2012)* that guided the development of the Next Generation Science Standards (NGSS).
- Field-testing in 2013–2016 with more than 400 teachers and 34,000 students around the country in a variety of geographic and demographic settings.
- Initial studies of program effectiveness showing significant student growth, conducted in first grade and middle school classrooms.

The research and development efforts to design Amplify Science were funded, in part, with grants from the Bill & Melinda Gates Foundation, the Carnegie Corporation of New York[1], the National Science Foundation[2], and the Department of Education's Institute of Educational Sciences[3].

Amplify Science is the result of a unique partnership between the University of California, Berkeley's Lawrence Hall of Science (also known as the Hall) and Amplify, who teamed up to design a curriculum specifically to address the NGSS that is firmly grounded in the latest research around science teaching and learning. The Hall based the pedagogy at the core of Amplify Science on the most rigorous research on best practices for science teaching and learning. Then, in collaboration with the instructional technology experts at Amplify, they created highly original, highly engaging instruction expressly informed by this pedagogical approach.

The program has resulted in strong learning outcomes in extensive field tests, as measured by assessments developed specifically to measure the deep conceptual understanding called for in the NGSS. Research studies currently in progress include a randomized control trial (RCT) being conducted by SRI International to further study the impact of the Amplify Science on student learning and to compare student learning from Amplify Science to student learning from other science curricula.

[1] Support for the development of Amplify Science was provided in part by a grant from Carnegie Corporation of New York.

[2] Amplify Science is based on work partially supported by the National Science Foundation under grant numbers DRL-1119584, DRL-1417939, ESI-0242733, ESI-0628272, ESI-0822119. The Federal Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

[3] Amplify Science is based on work partially supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A130610 to The Regents of the University of California. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Amplify Science is based on the latest research on best practices for teaching and learning science.

The Lawrence Hall of Science has done this before.

The mission of the Lawrence Hall of Science is to inspire and foster learning of science and mathematics for all, especially those who have limited access to science. The Hall investigates, creates, and evaluates educational materials and methods, professional development programs, and hands-on learning experiences for their science center, schools, communities, and homes. Hall programs have been proven effective in informal after-school environments and in K–12 classrooms. To address the challenges in science, technology, engineering and mathematics (STEM) education today, they have created a comprehensive set of programs to help increase the quality and quantity of science learning that children experience both in and out of school.

To develop Amplify Science, Amplify worked directly with the Hall's Learning Design Group, which focuses its research and development on the interface of science and literacy. The group describes itself as a team of dedicated researchers, curriculum and assessment specialists, disciplinary experts, and educational innovators who are creating powerful instructional sequences for the next generation of science learners. Their aim is to do more than help students learn about science. It is to enable all students to inhabit the role of a scientist and successfully use science to figure out scientific phenomena and solve real world problems.

The Hall not only grounds its work in the best available research, but also conducts its own studies to inform curriculum design and development. Its team supports those development efforts with iterative cycles of design and research, and subjects its own curriculum to rigorous efficacy studies.

The approach to instruction is grounded in research.

The Amplify Science program is built to embody the ambitious vision for science education articulated in the *Framework for K–12 Science Education (National Research Council, 2012)* and incorporates the latest research in student learning, including but not limited to:

- **Emphasis on coherence.** The third *International Association for the Evaluation of Educational Achievement's Trends in International Mathematics and Science Study (TIMSS)* identified curricular coherence as a major predictor of student performance (Schmidt, Wang, & McKnight, 2005). A curriculum that is coherent supports learners over time in building and linking ideas in order to develop an integrated understanding (Fortus & Krajcik, 2012; National Research Council, 2000).

  In order to structure students' exploration of the anchoring phenomena, and to ensure that students ultimately demonstrate competency with the unit's targeted Performance Expectations, Amplify Science units are designed around a Progress Build—a learning progression that culminates in the complex causal explanation that students should be able to make by the end of a unit (National Academies of Sciences, Engineering, and Medicine, 2017). Because Progress Builds carefully consider not only the knowledge students are likely to have at the beginning of a sequence of instruction, but also how the learning experience in the unit will position students for success with future learning opportunities, Amplify Science is able to support a consistent and coherent approach to instruction. Each unit's Progress Build was carefully developed in consultation with extant science education literature and then vetted, refined, and revised over the course of extensive field testing. In developing the units, the Progress Builds informed the design and maximized the coherence of each unit's sequence of learning experiences, and facilitated the productive integration of assessment and instruction (National Academies of Sciences, Engineering, and Medicine, 2017).

- **Real-world problems and roles.** Each Amplify Science unit introduces students to a realistic problem that they must solve by developing the ability to explain a surprising or mysterious phenomenon. The focus on "understanding phenomena" rather than on "teaching topics" provides structure and context to student investigations. Students also take on the role of a specific type of science or engineering professional, such as a food scientist or structural engineer, in order to solve problems facing the real world today. Such authentic learning experiences have been widely demonstrated to increase cognitive engagement in science learning (Blumenfeld, Kempler, & Krajcik, 2006; Potvin & Hasni, 2014).
- **Expanding investigation opportunities through digital enhancements.** Amplify Science is a digitally-enhanced curriculum, rather than a digital curriculum. Students interact with each other, with physical materials, and with text, and technology is used as a tool to strategically enhance learning in ways that take advantage of the unique affordances of technology. To that end, each core unit in grades 4–8 includes a custom-designed digital simulation ("sim"). Grades 2–3 include use of webcams and videos, and simple apps (called *practice tools*) that help students analyze data, visualize phenomena, and share their thinking. In contrast to more limited sims available on the internet and in other programs, Amplify Science sims are highly interactive microworlds that allow multiple levels of investigation and exploration that are carefully aligned with each unit's Progress Build.

Next Generation Science Standards

Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Our Do, Talk, Read, Write, Visualize approach has been proven effective.

Our core instructional approach is based on the multimodal model Do, Talk, Read, Write initially developed for the Hall's Seeds of Science/Roots of Reading® program for grades 2–5. This approach to instruction is highly congruent with research about effective science knowledge and literacy development; for example, science and literacy practices driven by inquiry are known to support rich and immersive learning (Pearson, Moje, & Greenleaf, 2010). The program was carefully studied and has gold standard evidence to show its efficacy. It was recognized as "a pioneer in cultivating science skills within literacy development as a powerful way to build students' reading skills and learn science content at the same time" (Carnegie, 2009).

Amplify Science evolved and extended the Do, Talk, Read, Write model to grades K–1 and 6–8 by conducting research and development with teachers and students in classrooms to determine the best ways to immerse older and younger students in science phenomena through multiple modalities. It was through this research that we added Visualize to the model to become Do, Talk, Read, Write, Visualize. Especially with the technology enhancements that Amplify brought to the partnership, we could enable students to visualize things that are too small, too big, too far away, too slow, or too fast to observe in firsthand ways. Adding regular instruction to support visualization aligns with the current educational emphasis on helping students create mental models of scientific phenomena. The Do, Talk, Read, Write, Visualize modalities align with the science practices described in the NRC Framework for K–12 Science Education, and embodied in the NGSS.

Each of these elements has been shown to support and enhance science learning. **Together, they provide a means of engaging students with particular concepts multiple times in multiple ways, and as a whole, they serve to shift student learning from "learning about" to "figuring out" science.**

Following is a breakdown of each core modality, with research supporting its efficacy.

Do, Talk, Read, Write, Visualize

Do

Learners engage with scientific phenomena by conducting student-centered investigations. Students collect evidence from a rich variety of evidence sources, including hands-on investigation with real phenomena; observations of primary sources such as video clips, photos, or another scientist's data; and through collecting evidence from physical and digital models. Students use this evidence to formulate a convincing scientific argument. While most agree that inquiry is essential to doing science, kit-based science approaches that focus on students' mainly doing activities have shown limited positive effects on learning (Slavin, Lake, Hanley, & Thurston, 2014). Approaches that also engage students in using evidence to support explanations and revise their ideas based on new evidence have the largest positive effects on learning (Furtak, Seidel, Iverson, and Briggs, 2012; Slavin et al, 2014).

Talk

Students engage in collaborative discussions and scientific argumentation. In general, student-to-student talk is a key component of a productive learning environment (Rivard & Straw, 2000; Duschl & Osborne, 2002; Varelas & Pappas, 2006; Varelas, et al, 2008), and Amplify features student talk as a key modality for instruction. We work to help teachers create learning environments that are both collaborative and inquisitive—where students feel comfortable challenging assumptions, probing for information, and ultimately learning from one another. Becoming a skeptical thinker takes practice; oral argumentation plays a central role in Amplify Science from kindergarten through grade 8 (Driver, Newton, & Osborne, 2001; McNeill & Krajcik, 2008; Osborne, 2010).

Read

Students engage in reading science text as an act of inquiry. They ask questions about what they read, gather evidence, and further investigate ideas, making connections to their own investigations. Just as science requires engaging in first-hand investigations, science also requires reading (Guthrie, Anderson, Alao, & Rinehard, 2001; Palinscar & Magnusson, 2001; Pearson, Moje, & Greenleaf, 2010; Romance and Vitale, 2001)—and students' ability to read complex disciplinary texts is a major predictor of science achievement on the ACT science exam (American College Testing, 2006). Amplify Science does not assume that students come to class knowing how to read science text. Beginning in kindergarten and continuing through grade 8, the program includes explicit instruction in reading science text and employs a "gradual release of responsibility" model (Anderson & Pearson, 1984; Duke, Pearson, Strachan, Billman, 2011; Pearson & Gallagher, 1983) to prepare students to become independent readers.

Write

Having an authentic purpose for writing both motivates students' interest in writing and drives their need for evidence to be convincing. In Amplify Science, students write to share what they have learned and also learn through writing (Yore, Bisanz, & Hand, 2003) as they apply new evidence to clarify and strengthen their written arguments. Amplify Science supports students in learning and using science academic language while they also learn to write like scientists, producing clear, logical, and evidence-based arguments and explanations.

Visualize

In addition to hands-on activities, reading, and writing, **students study a given phenomenon through carefully illustrated science texts, vivid digital simulations where they can manipulate variables, hands-on activities, and videos, as well as through modeling tools that allow them to visually represent their thinking.** Our custom-designed simulations allow students to see and investigate complex, microscopic, or otherwise unobservable phenomena (D'Angelo, et al., 2014; White, 1993).

Gold-standard research shows that this approach works.

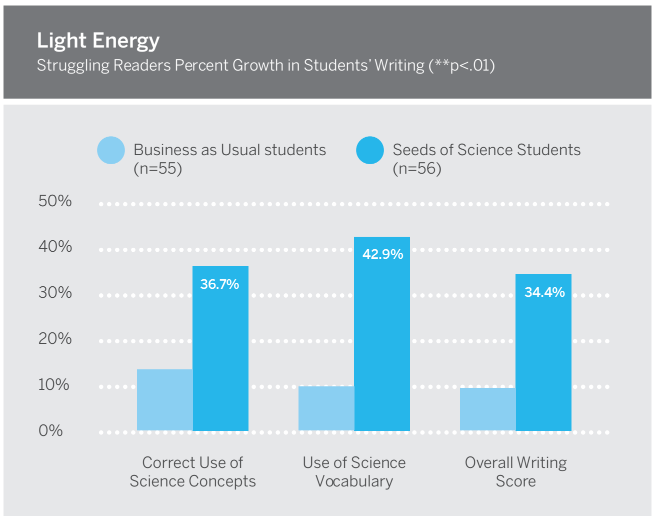
We know that students learn in many different ways, and we have evidence that our multimodal approach is effective for all students.

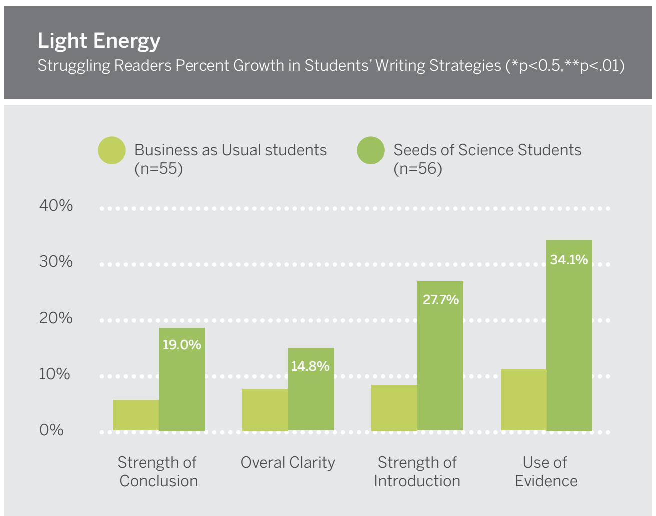
Three third-party gold standard studies (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Duesbury, Werblow, & Twyman, 2011; Wang & Herman, 2005) provide evidence that students who learn through the Do, Talk, Read, Write approach achieved more. Independent research groups, including The National Center for Research on Evaluation, Standards, and Student Testing at UCLA, compared students learning science through the Do, Talk, Read, Write approach to whatever curriculum was currently being used. Students using our Do, Talk, Read, Write approach benefited in a variety of ways:

1. **Students achieved more in both science and literacy.** Students engaging with our Do, Talk, Read, Write approach to learning science outperformed their peers on measures of both science and literacy: measures of science conceptual knowledge and science vocabulary. (Cervetti et al, 2012; Duesbury, Werblow, & Twyman, 2011; Wang and Herman, 2005).

2. **Student writing and reading comprehension improved.** Students who used our approach also performed equivalently to or higher than control students on measures of science reading comprehension and science writing—even though teachers reported spending less time teaching their usual literacy program (Cervetti et al, 2012). Compared with that of their peers, students' writing included more use of evidence, more science vocabulary, more accurate use of science concepts, and arguments with stronger introductions and conclusions.

3. **English Language Learners excelled.** English Language Learners (ELLs) significantly outperformed other ELLs in reading comprehension, science vocabulary, and science content knowledge (Duesbury, Werblow, & Twyman, 2011).





The charts above show show percent growth over the course of one unit of study. These results are specific to Seeds of Science/Roots of Reading, which includes the Do, Talk, Read, Write approach that is expanded upon in Amplify Science. This data represents students who scored in the bottom quartile.

Our own testing shows that Amplify Science works.

Field trials: here's what we've seen and are excited about.

First grade study

With support from the Department of Education's Institute of Educational Sciences, two first grade units (one life science and one physical science) were field tested in five predominantly English-learner schools. The goals of the study were to understand how effectively each unit performed in supporting student science learning and to understand the potential for impact on student reading comprehension of science texts related to the unit content.

In each study, the effectiveness of the unit was determined by comparing scores on pre- and post-unit assessments of students experiencing the field trial unit to scores for a similar number of students in classrooms using the district-mandated curriculum. The measures included assessments of science knowledge, science vocabulary knowledge, and reading comprehension of science topics related to the unit. The science knowledge and vocabulary knowledge measures were administered in one-to-one sessions with each student and the reading comprehension measure was administered to each class of students. Student growth was calculated using percent growth and effect size measures based on correct responses. Growth in science knowledge was also scored using rubrics to rate student use of science vocabulary and explanatory language structures. **Results show that the Amplify Science pedagogical approach is effective for young learners.**

Key results

- Students learn science. Students in classrooms using the field trial units outperformed their peers on all measures of learning, with effect sizes ranging from small to large (.14<ES<.88) and an average effect size of 0.45. In particular, students' ability to describe and explain science concepts improved.
- Students strengthen reading comprehension skills while learning science. Students demonstrated statistically and educationally significant growth on reading comprehension of passages related to the unit science content.

Middle school

Amplify Science for grades 6–8 was field tested over a two-year period with more than 475 teachers and 34,000 students in cities, suburbs, and rural communities across the country. We sought to understand how effective each unit was in achieving the learning objectives, and how teachers and students responded to the material. 16 units spanning Earth and Space, Life, and Physical Sciences were tested in partnership with middle schools.

Using a pre-experimental design, we evaluated the program's effectiveness through both the observed outcomes (i.e. student growth in learning) and the experience (i.e. teacher satisfaction). For each unit, students responded to an assessment prior to instruction and again immediately following instruction. Each of these pre-unit and post-unit assessments was scored and student growth was calculated using percent growth and effect size measures. Teacher feedback was collected through daily surveys.

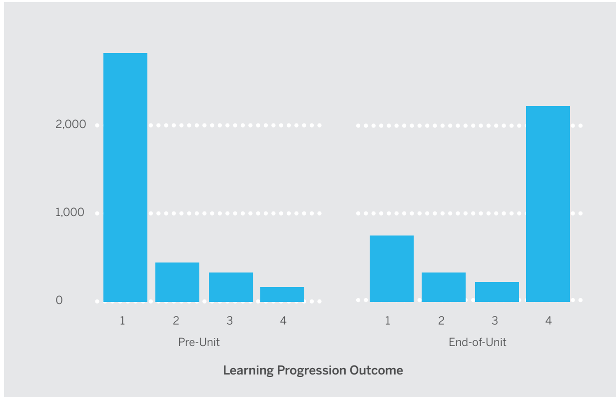
Key results

- **Students learn science.** Learning outcomes were measured as percent correct scores on the pre-unit and post-unit assessments. Across all units, the average effect size was 0.84 (Cohen's d) and average percent growth was 45%. You can see the movement through the Progress Builds, or learning progressions, on the following page. **In everyday terms: students make significant progress through the learning progression after completing each unit.** These were encouraging results and the data were used to further improve the program before its final publication.
- **Teachers love it.** Nearly all teachers surveyed indicated that, if given the option, they would choose to use Amplify Science again in their classrooms. The vast majority thought the program was effective and enjoyed by students, addressed the needs of diverse learners, and was generally better than other curricular materials they have used in the past. Five out of six teachers said that Amplify Science is better than their usual curriculum at engaging students in scientific discussions and at supporting students to write scientific arguments. Notably, 99 percent of teachers thought the simulations were helpful, enjoyed by students, and appropriately complex.

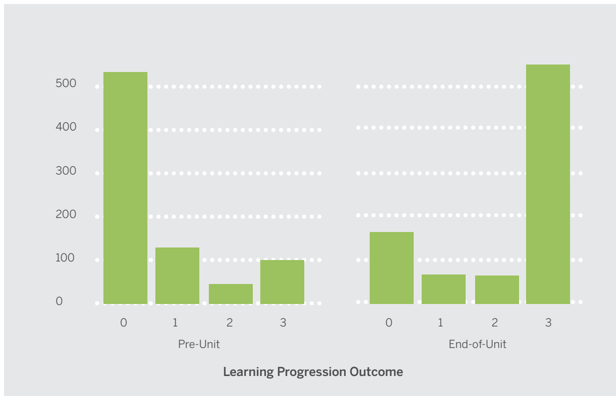
Recent results

After reworking the program based on feedback obtained from the field trials, we began supporting full implementations. The results shown here are from classrooms across the country who started implementing in the fall of 2017 or later. The most notable data point in these graphs is the number of students who moved from the lowest to highest level in the learning progression (from 0 to 3 in their "Progress Build") over the course of the unit (generally 6 weeks).

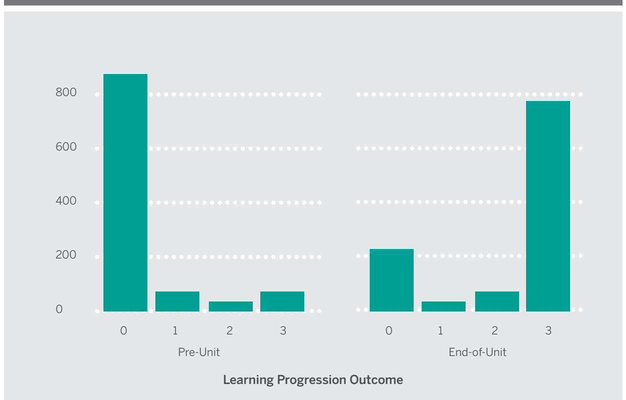
Traits and Reproduction Assessment Results
Progress Build distribution for all schools, 2017–2018 school year



Chemical Reaction Assessment Results
Progress Build distribution for all schools, 2017–2018 school year



Weather Patterns Assessment Results
Progress Build distribution for all schools, 2017–2018 school year



The charts above show movement through the learning progression over the course of one unit of study. The learning progression in Amplify Science is outlined in what we call the Progress Build.

The program is performing well based on internal measures for student mastery.

These results meet the requirements of Every Student Succeeds Act (ESSA) Tier 4 (Demonstrates a Rationale), showing that there is a well-founded rationale for the approach. Programs meeting these requirements have a well-defined logic model or theory of action, are supported by research, and have some effort underway by an SEA, LEA, or outside research organization to determine their effectiveness (Every Student Succeeds Act, 2015).

ESSA replaced No Child Left Behind (NCLB) in 2005, using a higher evidence standard than NCLB. While the NCLB guidelines around instructional materials required that programs be "based on scientifically based research"—a standard that could, in theory, apply to any program—ESSA "uses a higher standard, requiring programs to have been tested and found to be significantly more effective than standard practice" (Every Student Succeeds Act, 2015).

The preceding sections outlined the logic model (in ESSA terms, theory of action) behind Amplify Science. As we prepare for studies demonstrating the program's efficacy, we have preliminary evidence to show that the program is achieving the relevant outcomes.

The following section details additional research currently underway to meet the higher standards of evidence under ESSA. These remaining three levels are: **Tier 3: Promising Evidence** (supported by one or more well-designed and well-implemented correlational studies, with statistical controls for selection bias); **Tier 2: Moderate Evidence** (supported by one or more well-designed and well-implemented quasi-experimental studies); and **Tier 1: Strong Evidence** (supported by one or more well-designed and well-implemented randomized control experimental studies).

The table below shows average student knowledge growth from the 2016–2017 and 2017–2018 school years. The student knowledge growth is the amount by which the percent correct scores changed from Pre-Unit Assessment to the End-of-Unit Assessment.

School Year	Student Knowledge Growth
2016–2017	88.63%
2017–2018*	89.91%

* Fall semester only

The "Student Knowledge Growth" metric summarizes the growth in pre-post assessment scores across the program. Relevant outcomes are in the positive direction, indicating a favorable outcome. These results are highly encouraging and the suggested effects will be investigated further, as described on the next page.

We have research underway that will shed even more light.

Our own analyses will take a closer look at effectiveness.

Promising evidence (Tier 3): Schools who have used Amplify Science have seen an increase in their state-level science exams. We are actively working with school districts to gather and analyze these data from the 2017–2018 school year. We are working toward publishing the results of these case studies in 2018.

An impact study will look deeply at the efficacy of the program.

Strong evidence (Tier 1): To meet the ESSA standard for strong evidence, Amplify Science will undergo a randomized control efficacy study in the 2018–2019 school year. This impact study will be conducted by SRI International (SRI), an independent third-party research organization. Preliminary results are expected in 2019.

About Amplify Science

A collaboration between the curriculum experts at University of California, Berkeley's Lawrence Hall of Science and the instructional technology experts at Amplify, Amplify Science was built to address 100 percent of the Next Generation Science Standards while developing students to be curious, skeptical, evidence-based thinkers.

Amplify's products and services help educators improve the way they integrate technology and use data in the classroom, and is built on the foundation of Wireless Generation, the pioneer of mobile assessments and instructional analytics for schools. Amplify has supported more than 200,000 educators and 3 million students in all 50 states.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Amplify.

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