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Supporting Science Learning and Literacy Development Together:

Initial Results From a Curriculum Study in 1st Grade Classrooms

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Note regarding the independent nature of the study:
This study was conducted by WestEd in partnership with LFC Research (Robert Murphy) and SRI Education (Daisy Rutstein). Amplify Education, Inc., which is the publisher and distributor of Amplify Science, was not involved in the administration of the study. Developers from the University of California in Berkeley's Lawrence Hall of Science provided the professional learning support that was part of the curricular intervention. The Lawrence Hall of Science also served as a resource and thought partner to the study team on matters related to the curriculum, its design features, and its implementation. All data collection and analysis activities were carried out independently by the study team.

CONTENTS

SUMMARY

This report describes initial findings from a study conducted in 1st grade classrooms of science curriculum materials that were designed to promote learning as called for by the Next Generation Science Standards (NGSS). The study, led by WestEd, was an independent randomized controlled trial to evaluate the efficacy of the NGSS-designed Amplify Science 1st grade curriculum. The curriculum aims to support science language and literacy in day-to-day science lessons in ways meant to integrate science learning with students' literacy development.

The study examined the impact of the curricular materials in classrooms across three school districts within a state that has adopted NGSS performance expectations. Elementary schools were randomly assigned to one of two implementation conditions: an intervention condition in which 1st grade teachers implemented the Amplify Science program and a comparison condition in which 1st grade teachers continued their regular classroom science instruction. In both conditions, teachers were tasked with covering the same topics in physical science, life science, and Earth and space science as outlined by their respective districts and state standards. Teacher implementation measures included weekly instructional logs in which teachers self-reported on their science instruction. Student outcome measures encompassed four types of assessments: a standardized science assessment, a science assessment aligned with NGSS performance expectations, an assessment focusing on science vocabulary usage aligned with domain-specific language emphasized by the NGSS, and a standardized 1st grade reading assessment.

The results show that students in intervention classrooms significantly outperformed students in comparison classrooms on the two NGSS-focused assessments. A small positive effect was found on the standardized science assessment that was distal to the NGSS. There was no difference between the two conditions on the standardized reading assessment, indicating that students' reading performance in the two conditions were similar at the end of the school year. This suggests that the intervention may have supported students' reading development while providing them with considerably more science instruction. This study is among the first randomized controlled trials of widely available curriculum materials for the NGSS in K–3 classrooms.

INTRODUCTION:
The Status of Elementary Science in the Context of Today's Vision for Science Education

This is a time of impressive change for science education, as a new generation of science curriculum materials is being developed across all levels of K–12. Catalyzed by the release of *A Framework for K–12 Science Education* (National Research Council [NRC], 2012) and the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013), these new and innovative curriculum materials are playing a pivotal role in transforming science instruction to actively engage students in authentic science learning. The *Framework* and NGSS underscore the importance of affording every student, starting from the earliest grades, the opportunity to participate in science, where they need to go beyond just learning the factual information about a science topic and toward figuring out and explaining how or why something happens in the natural world. In this way, the *Framework* and NGSS recast science proficiency as not only what students know but also how they can use and apply what they know to make sense of phenomena and design solutions to problems.

While this vision holds tremendous promise for engaging a diverse range of students in science learning, the unfortunate reality is that most young students do not have access to high-quality elementary science education (e.g., Trygstad et al., 2020). Science has long been undervalued in the elementary grades (Spillane et al., 2001), with the amount and quality of science instruction varying widely (e.g., Banilower et al., 2013; Banilower et al., 2018; Dorph et al., 2011; Marx & Harris, 2006). For example, the findings of the *National Survey of Science and Mathematics Education* (NSSME) over the past 20 years (e.g., Banilower et al., 2013; Banilower et al., 2018; Weiss et al., 2001) consistently show that science receives far less instructional time than do other core subjects during the early grades.

At the same time, there is increasing recognition that early science education is important for all students, especially those whose backgrounds are underrepresented in science and science-related fields (e.g., McClure et al., 2017; National Academies of Sciences, Engineering, and Medicine [NASEM], 2022). Students in underresourced schools often progress through the elementary years with far less access and fewer opportunities to learn science, thereby creating a discouraging situation of inequitable science access that has potential long-term consequences (Dorph et al., 2011; Marx & Harris, 2006; Morgan et al., 2016).

A reason often given for the diminished instructional time for science is that language arts and mathematics are considered paramount in early elementary classrooms. Accountability policies,

mostly intended to support robust language arts and mathematics instruction, have the unintended consequence of pushing science to the sidelines. Moreover, lowered prioritization of science learning by education leaders and policymakers often translates to a lack of investment in updated instructional materials, professional learning, and supplies needed for science. This dilemma presents a significant challenge for the science education community:

> ***Without diminishing the important aims of language arts and mathematics, how can we build and sustain quality science education that is accessible to all students, beginning in the earliest grades?***

The renewed interest and enthusiasm in science education for the early grades have led to the development of new curriculum materials expressly designed to fit within the current reality of elementary classrooms. One example is the Amplify Science K–5 curriculum, which received high marks for its NGSS design in a review by EdReports (EdReports, 2022). The materials, developed by the University of California, Berkeley's Lawrence Hall of Science, in collaboration with Amplify Education, Inc., aim to promote learning as called for by the NGSS. The use of these curriculum materials in elementary classrooms requires teachers to spend more instructional time on science than is typical based on national surveys of K–5 elementary teachers (Banilower et al., 2018). Noteworthy is that the curriculum's day-to-day science lessons intentionally integrate science learning with students' literacy development, with an emphasis on reading in K–3. The lessons engage students in multiple learning modalities (i.e., doing, reading, writing, talking, and visualizing science) with attention to age-appropriate pedagogy. This integration offers the potential benefit of more instructional time for science while enabling teachers to simultaneously support young students' literacy development in the context of science.

In this report, we describe initial findings from a study of the NGSS-designed Amplify Science program in 1st grade classrooms. The study team investigated the impact of the materials in 1st grade classrooms across three school districts in a state that has adopted NGSS performance expectations. Of high interest was studying the extent to which the curriculum supports young students' three-dimensional learning as called for by the NGSS,[1] their literacy learning related to reading and the use of science-related language, and the nature of teachers' implementation. This report presents initial findings on science and literacy learning outcomes and discusses the

[1] Three-dimensional learning refers to the process of applying the three dimensions of disciplinary core ideas, science and engineering practices, and crosscutting concepts to make sense of phenomena or solve problems. It is the means through which students are expected to build proficiency with NGSS performance expectations.

implications of these findings for science instructional practice in K–3 classrooms. In particular, the discussion considers the promise of NGSS-designed curriculum materials for supporting the teaching and learning of science and literacy development together in the early elementary grades.

STUDY OVERVIEW

WestEd led an independent randomized controlled trial to evaluate the efficacy of the NGSS-designed Amplify Science 1st grade curriculum. The 1st grade curriculum was originally developed by the Lawrence Hall of Science under a development grant from the U.S. Department of Education's Institute of Education Sciences and is now part of the comprehensive Amplify Science K–5 program that is widely available to school districts. In the study reported here, the research team investigated the extent to which the curriculum supports young students' three-dimensional learning as called for by the NGSS and their literacy learning related to reading and science language use:

> ***What is the impact of the 1st grade curriculum on science learning and literacy outcomes in culturally and linguistically diverse school settings?***

Study Design

To study the impact of the NGSS-designed Amplify Science materials, we conducted a randomized controlled trial in 1st grade classrooms across 40 schools in three districts in California during the 2021/22 school year.[2] Within each district, elementary schools were randomly assigned to either an intervention or comparison condition, with all teachers in a school receiving the same assignment. The 1st grade teachers in the intervention condition implemented the Amplify Science curricular units as part of their regular classroom instruction and received professional development on the curriculum. Teachers in the comparison condition implemented their regular classroom instruction without Amplify Science and were asked to teach science as they typically would during the school

[2] Originally scheduled for the 2020/21 school year, the study was postponed to the following year due to the COVID-19 pandemic. All schools provided in-person, classroom-based instruction during the 2021/22 study.

year.[3] Teachers in both groups were tasked with providing instruction on the same science topics and to support students in building proficiency with the same NGSS performance expectations as outlined in their state standards for 1st grade.

Setting and Participants

The participating districts are located in different geographic regions and represent a range of diverse student populations. They vary in size and type, including a large urban district, a large rural district, and a midsize suburban district. Collectively, they serve diverse student populations, including multiple racial and ethnic groups. Approximately 30 percent of students across all schools were identified as multilingual learners, and nearly 70 percent qualified for free or reduced-price lunch. Most schools in the sample are Title I schools. The sample consisted of 39 teachers within 18 schools assigned to the intervention condition and 43 teachers in 22 schools assigned to the comparison condition. The analytic sample included 2,035 students from the 82 classrooms of 1st graders.

Randomization

To conduct the randomization process, enrolled schools within each district were paired based on their demographic characteristics and students' prior performance on state mathematics and English language arts tests. Then, within each pair, schools were randomly assigned to either an intervention condition or a business-as-usual comparison condition. Randomizing within districts ensured that both the intervention group and the comparison group included schools from all participating districts. Moreover, using matched pairs to randomize increased the likelihood of a balanced sample.

Amplify Science 1st Grade Curriculum

Amplify Science's 1st grade curriculum consists of three phenomena-based instructional units, each focusing on one of three science domains: life science, physical science, and Earth and space science. The life science unit engages students in the study of plant and animal survival, exploring plant and animal structures and functions, including how parents and offspring are alike but not exactly alike. Students build models to explain how animals and plants survive in their environments. The physical science unit addresses light and sound, engaging students in investigating cause-and-effect patterns related to light, light interactions with materials, and sound. The Earth and space science unit integrates two big ideas: the patterns in the sky as observed from

[3] Of note is that participating districts were offered the Amplify Science curriculum package for their comparison group teachers along with professional learning for the subsequent year once the study concluded.

Earth and Earth's shape, position, and motion as observed from space. Students investigate and explain nighttime and daytime patterns, the apparent motion of the sun in the sky, and seasonal patterns. Across the three units, lessons are designed to engage students with NGSS disciplinary core ideas, science and engineering practices, and crosscutting concepts.

Each unit is 22 lessons in length and designed to be taught within a 6–8 week period, with students participating in two or three lessons per week. Lessons are 45-minute sessions but can be divided and presented over a greater number of sessions. The curriculum is hosted on a digital platform for teachers, offering features that enable the download of the teaching guide, lessons, and all supporting documents. Throughout the units, students conduct hands-on investigations; read; gather information from various sources, such as books, videos, and images; and participate in discussions and writing activities to explain science ideas. They collect evidence from firsthand investigations and secondhand sources to create physical models and write explanations. The curriculum package includes the following:

- a digital teacher's guide and media for students
- science kit materials with literacy supports
- student notebooks for writing and drawing
- five books provided as big books for teachers for read-aloud, shared, and partner reading and student books for the same purposes

Intervention and Comparison Conditions

Teachers in the intervention condition were provided with the full-year Amplify Science curriculum package and received 3 full days of professional learning on the instructional stance of the overall curriculum, the features of the units, and how to implement the lessons. These professional learning sessions were facilitated by the developers from the Lawrence Hall of Science who had designed the 1st grade units. Prior to the start of the school year, teachers attended a 1-day workshop to learn about the curriculum's integrated science and literacy pedagogical approach, to experience segments of the target curriculum units as learners, and to become familiarized with the digital teacher's guide. Two additional professional learning sessions were held during the school year just before the teaching of the second and third units. In addition to gaining experience with the content of the targeted units, the second and third workshops provided time for teachers to share their experiences with implementing integrated science and literacy instruction and to seek advice from fellow teachers as well as the professional learning providers. In cases when teachers could not attend a session during the school year, they were offered the option of attending a makeup video conference with the facilitators or watching a recorded session with an accompanying brief activity to complete.

Teachers in the intervention condition were instructed to implement the three Amplify Science units and adhere to their district's science sequence aligned with NGSS performance expectations. Meanwhile, teachers in the comparison condition were asked to teach science as they normally would and follow their district's science sequence aligned with NGSS performance expectations.

To ensure that all teachers had familiarity with the study's requirements, teachers in both conditions participated in a virtual session hosted by the research team at the beginning of the school year. This session provided an overview of the study, the study's timeline, and data collection activities. Separate research sessions were held for each group of teachers. Throughout the study, the research team had dedicated staff members serve as coordinators who were responsible for communicating with all participating teachers about study-related matters, coordinating data collection from classrooms, and tracking teacher participation in study activities.

MEASURES

Student Learning Measures

The outcome measures included two standardized assessments of science and reading and two study-developed NGSS-focused assessments of science learning and science vocabulary in-use.

The Iowa Assessments for Grade 1 provide a standardized measure of within-year student achievement in reading and general science knowledge. The reading comprehension assessment consists of a series of five short stories. Students read the stories and answer three or four multiple-choice items for each story without assistance by the teacher. The Iowa Assessment for science consists of 29 pictorial items administered to the whole class. For each item, students are presented with three pictures, and the teacher reads a question aloud. Students then mark the circle under the picture that best answers the question. These items cover general knowledge in life science, physical science, and Earth and space science but are not aligned with NGSS performance expectations.

At the time of the study, there were no off-the-shelf 1st grade science assessments for the NGSS. Subsequently, the research team developed two NGSS-focused assessments that would be fair to both study conditions (DeBarger et al., 2016). The first is a science learning assessment that was designed to elicit student performance with aspects of NGSS performance expectations for 1st grade. This assessment consists of six multistep tasks within a booklet—two from each of the domains of Earth and space science, life science, and physical science. For each task, students are presented with a brief phenomenon-based or problem-based scenario that requires them to

demonstrate a range of performances that include interpreting data in tables, drawing, making predictions, and selecting tools for an investigation. This assessment was administered as a whole-class activity in which the teacher read each scenario aloud while students followed along and responded in their own booklets.

The second NGSS-focused assessment is a science-vocabulary-in-use assessment aligned with domain-specific language emphasized by the NGSS. It prompts students to evaluate word meaning and usage. It consists of 10 science terms relevant to the three dimensions of NGSS performance expectations (i.e., science and engineering practices, disciplinary core ideas, and crosscutting concepts) for 1st grade. For this assessment, students are presented with each term and asked whether they agree with two provided definitions (one not aligned with the science term) and then asked to respond to two questions related to the appropriate use of the term in a science context. This assessment was delivered as a whole-class activity, with the teacher reading the prompts aloud while students filled in circles corresponding to their chosen answers in their own booklets.

Collecting and Scoring Completed Assessments

Teachers in both conditions were asked to administer the full battery of paper-and-pencil assessments within 2 weeks of concluding their science instruction for the year. All completed standardized assessment response forms underwent automated scoring to generate scale and raw scores. The NGSS-focused assessment forms were randomized and assigned to independent scorers with expertise in science education and science assessment. Responses were scored using rubrics and scoring guides. Scorers underwent rigorous training on the rubrics, with one set of assessments serving as a training set. During scoring, the scorers remained blind to all identities, including the assigned research condition. Approximately 25 percent of the assessments were scored by two scorers with checks for reliability. Any disagreements were resolved by a third scorer. Following an initial reliability check, the interrater exact agreement reliability exceeded 90 percent with Cohen's kappa scores of greater than 0.8 across all items. Scores from tasks were aggregated to calculate an overall total score for each assessment. After completing the scoring, the psychometric properties of the NGSS-focused assessments were examined. The overall internal consistency as measured by Cronbach's alpha was 0.674 for the science learning assessment and 0.845 for the science-vocabulary-in-use assessment.

RESULTS

To gauge the impact of the Amplify Science 1st grade science curriculum on student learning outcomes, we compared posttest scores of students in intervention schools with those of students in comparison schools across the four assessments (i.e., NGSS-focused assessments and standardized assessments). Our analysis employed multilevel linear regression models with students nested within schools. We controlled for a range of school-level and student-level characteristics, as well as for students' prior achievement on reading tests administered by each district at the beginning of the school year.

Finding 1

Students in intervention classrooms significantly outperformed students in comparison classrooms on NGSS-focused three-dimensional learning and science vocabulary in-use.

The 1st grade students in classrooms that used Amplify Science materials achieved higher scores on both end-of-year NGSS-focused assessments. The estimated impact on performance on the science learning assessment was statistically significant ($p < .001$) and corresponds to an effect size of 0.24 standard deviation units (Hedges's g). The estimated impact on performance on the science-vocabulary-in-use assessment was also statistically significant ($p < .01$) and corresponds to an effect size of 0.46. Moreover, these same students slightly outperformed their counterparts in comparison classrooms on the standardized science assessment that is distal to the NGSS. We observed a small positive effect size of 0.09 on the standardized Iowa assessment for science, although the mean difference in scores between students in intervention and comparison classrooms was not statistically significant ($p > .60$).

Effect sizes are a common metric in educational research to quantify the magnitude of the difference between two groups. They can be especially helpful for understanding the practical significance of intervention effects. The effect sizes for student performance on the NGSS-focused assessments are considered meaningful for education research. To put this in perspective, an effect size of 0.24 on the science learning assessment is equivalent to the average student in the comparison classrooms improving their percentile rank by 10 percentile points (e.g., from the 50th percentile to the 60th percentile) if they had access to the Amplify Science curriculum. Similarly, an effect size of 0.46 on the science-vocabulary-in-use assessment is equivalent to an improvement from the 50th percentile to the 68th percentile for the average comparison student, or 18 percentile points. The small effect size of 0.09 on the standardized Iowa assessment for science is negligible, meaning that the average student in comparison classrooms would perform about the same or improve only slightly if assigned to the Amplify Science curriculum.

Finding 2

Students in intervention classrooms performed similarly to students in comparison classrooms on a standardized assessment of reading.

We collected student reading benchmark scores at the beginning of the school year as a measure of prior academic achievement. There were no statistically significant initial differences between the Amplify Science intervention and comparison groups on achievement scores in reading. At the end of the school year, we found that students who had access to the Amplify Science curriculum remained on par with students in comparison classrooms. That is, there were essentially no differences in performance between 1st grade students in intervention and comparison classrooms on the standardized Iowa reading assessment. The effect size was below 0.01. This result suggests that the literacy-focused aspects of the Amplify Science curriculum may be playing a role in supporting students' reading development in intervention classrooms as they spend significantly more of the school week engaged in science instruction.

DISCUSSION AND CONCLUSIONS

The learning outcome results provide promising evidence that curriculum materials designed for the early grades to support NGSS instruction can enhance student learning of important three-dimensional learning goals found in state science standards. In this study, the state science standards for all participating districts took the form of NGSS performance expectations for 1st grade. Moreover, the results show that science curriculum materials that use the high-leverage strategy of integrated science and literacy can improve students' proficiency with science, enrich their science vocabulary knowledge and usage, and simultaneously develop their reading skills. The NGSS-focused assessments were designed to be instructionally sensitive by aligning with the state science standards that teachers were held accountable for within both conditions. In contrast, the standardized science assessment measured general science knowledge that was distal to the three-dimensional learning goals of the state standards. We found no significant difference in students' general science knowledge between conditions.

The findings from the standardized reading assessment are intriguing because they appear to suggest that teachers can teach considerably more science in the early grades using Amplify Science with some confidence that students' reading scores will not be negatively impacted. Our ongoing analysis of teachers' instructional logs and survey responses (not described in this report) will enable us to further explore how the materials were used in classrooms and the time devoted to using them. Noteworthy is that in prior implementation research of Amplify Science materials in 1st grade classrooms, we found that teachers who implemented the curriculum spent considerably more time on science instruction than did their counterparts in comparison classrooms (Iveland et al., 2021). When they did teach science, these teachers were more likely to engage their students in reading informational science text and communicating their science ideas orally, in drawing, in model use, and in writing. They were also more likely to engage their students in a range of science and engineering practices and support student sense-making of phenomena. In the present study, we are currently investigating these same aspects of teaching and the amount of time spent in science instruction between intervention and comparison classrooms.

Curriculum materials that bring together science and literacy in a manner that benefits learning in both domains may enable elementary teachers to create the instructional space needed for science to be taught on a regular basis. The research literature on the benefits of science and literacy integration in the elementary grades has been well documented and is quite compelling (e.g., Billman & Pearson, 2018; Cervetti et al., 2012; Samarapungavan et al., 2011; Varelas et al., 2006). Yet, the teaching of science has not been prioritized in the elementary grades historically. High-quality science curricular materials that fit with the current realities of schools and meet the needs of teachers and young students are an important start, but they are likely just one of several

components that will be required to shift an elementary system in which long-standing policies and practices have made providing early grades access to science a formidable challenge.

Finally, there have been relatively few studies in the elementary grades of science and literacy integration in the context of NGSS-designed curriculum materials. This study contributes to this emerging literature and is among the first group-randomized studies of widely available curriculum materials for the NGSS in K–2 classrooms. As Amplify Science K–5 and other new NGSS-designed materials become more widely used across geographic regions and with varying student populations, additional studies at larger scale will be needed so that we can continue to build the evidence base for the uptake of science in the elementary grades.

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