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# Curriculum Materials Designed for the Next Generation Science Standards Show Promise

## Initial Results From a Randomized Controlled Trial in Middle Schools

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**January 2022**

*Research Brief Report*

Suggested citation: Harris, C. J., Feng, M., Murphy, R., & Rutstein, D. W. (2022). *Curriculum materials designed for the Next Generation Science Standards show promise: Initial results from a randomized controlled trial in middle schools*. WestEd.

The contents of this report are based upon work supported by the National Science Foundation under Grant No. DRL-1913317. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of their respective institutions or the National Science Foundation.

**Acknowledgements**

We extend thanks to Eunice Chow, Kevin Huang, Ashley Iveland, Gillian Kpodjie, Charlie Mahoney, Ruchita Patel, Melissa Rego, and Elli Suzuki for their contributions to this research and to Elizabeth Arnett for assistance in preparing this report. We gratefully acknowledge the support of district leaders and the participation of the teachers and students within the districts where this study was conducted.

# Summary

This report describes initial findings from a study of middle school science curriculum materials that were designed to promote learning as called for by the Next Generation Science Standards (NGSS). WestEd led an independent randomized controlled trial to evaluate the efficacy of the NGSS-designed Amplify Science Middle School (ASMS) curriculum. This study examined the impact of the materials in 7th grade classrooms across three school districts in two states. Schools were randomly assigned to one of two groups: an intervention group in which teachers implemented ASMS and a comparison group in which teachers implemented their regular curricular units. Science teachers in both groups implemented instruction that aimed for the same NGSS performance expectations. Hierarchical linear regression modeling was used to analyze the impact of the curriculum on student learning outcomes in physical science, as measured by an assessment aligned to NGSS performance expectations. Initial findings show promise that the ASMS curriculum can be used to support next generation science learning. The main result was that students in intervention classrooms significantly outperformed students in comparison classrooms. This study is among the first rigorous studies of widely available curriculum materials for the NGSS.

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# Introduction: Today's Vision of Science Learning

*A Framework for K–12 Science Education* (National Research Council, 2012) and the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) articulate an ambitious vision for what students should know and be able to do in science. The *Framework* and the NGSS emphasize that all students must have the opportunity to learn and actively participate in science through using and applying disciplinary core ideas (DCIs) in concert with science and engineering practices (SEPs) and crosscutting concepts (CCCs) to make sense of phenomena or to solve problems. Central to this vision is the notion of three-dimensional learning, wherein students use the three dimensions of DCIs, CCCs, and SEPs as the means through which to build the proficiencies required to meet the NGSS performance expectations. The performance expectations express the integrated goals for three-dimensional learning. They specify what students should know and be able to do in science at a given grade level or across a grade band.

Many science educators and scientists embrace the vision described in the *Framework* and instantiated in the NGSS (e.g., National Science Teachers Association [NSTA], 2016), and the vast majority of states, representing more than 70 percent of the U.S. student population, now have standards influenced by the *Framework* and/or the NGSS. Today, this vision for science education has become policy in many corners of the United States, with NGSS performance expectations articulated in the standards of all states that fully adopted the NGSS and in the science standards of many states whose standards are based on the *Framework*.

Increasingly, new curriculum materials are becoming available to support teachers in providing instructional experiences that will engage their students in three-dimensional learning. Many are being designed to meet the ambitious call of the NGSS and to address the performance expectations that are found in state science standards. As these NGSS-designed curricula are implemented more widely, it will be important to conduct evidence-based research on their efficacy.

# The Study

WestEd led a randomized controlled trial to examine the efficacy of the widely available Amplify Science Middle School (ASMS) curriculum for advancing 7th grade students' learning in relation to NGSS performance expectations. The ASMS materials, developed by the University of California, Berkeley's Lawrence Hall of Science in collaboration with Amplify Education, Inc., are among the first comprehensive curricular programs that have been designed specifically to meet the vision of the *Framework* and to address the performance expectations of the NGSS. The research team investigated the extent to which the curriculum supports students' three-dimensional learning and the nature of teachers' implementation:

- *Student learning:* What is the impact of the ASMS curriculum on learning outcomes in culturally and linguistically diverse school settings? How does the impact of the ASMS curriculum vary by student background characteristics?
- *Curriculum implementation:* What is the nature of teachers' implementation of the ASMS curriculum? In what ways does implementation of the ASMS curriculum influence teachers' NGSS instruction?

This report describes findings on student outcomes in physical science and presents initial findings related to the implementation of ASMS curriculum and its impact on teachers' instructional practice.

## Study Design

To test the impact of the ASMS curriculum materials, we conducted a randomized experiment in 7th grade science classrooms across 15 schools in three districts during the 2019–2020 school year. The districts in the study were in different geographic regions and represented a range of diverse student populations. Schools within districts were randomly assigned to either an intervention group or a comparison group.

- Teachers in the intervention group implemented the ASMS curriculum and received accompanying professional learning support provided by the Lawrence Hall of Science developers.
- Teachers in the comparison group implemented their regular curricular materials and received science professional learning that was typically offered by their districts.
- Teachers in both groups were asked to cover the same science topics and provide instruction that aimed to support students in building proficiency with the same NGSS performance expectations.

The study included multiple measures of student learning outcomes, implementation, and teacher instructional practice. The implementation and instructional practice measures were in the form of weekly instructional logs and teacher surveys. In this report, we focus on (a) the assessment of student learning for physical science that was administered in both groups and (b) teacher log and survey data from the intervention group related to ASMS implementation.

## Setting and Participants

The participating middle schools were from three districts across two states whose science standards were informed by the *Framework* and NGSS. Notably, both states have NGSS performance expectations as part of their science standards for the middle grades. The districts are of varying size (i.e., large, midsize, small) and serve diverse populations that include multiple racial and ethnic groups, English Learners, and students who qualify for free or reduced-price lunch. Most schools in the sample are Title I schools. The sample included 15 science teachers within eight schools assigned to the intervention group and 13 science teachers within seven schools assigned to the comparison group. The student sample included 1,780 students from the 28 teachers' classes.

### A note about the broader study context

The study reported in this research brief was part of a broader yearlong experimental study of the ASMS curriculum materials that involved 29 middle schools across four districts. The year-long study was underway during the 2019–2020 school year when the COVID-19 pandemic caused school closures in early spring 2020. This brief describes findings from the classroom-based research that was conducted in 15 of the schools within three districts where physical science assessment data collection was successfully completed prior to school closures.

## Randomization

Middle schools within each district were paired based on their demographic characteristics and prior student performance on state math and ELA tests and then, within each pair, randomly assigned to an intervention group or comparison group. Randomizing within districts ensured that both the intervention group and the comparison group included schools from all participating districts. All 7th grade teachers in a given school had the same assignment: they implemented either the ASMS materials or their "business as usual" materials during the 2019–2020 school year. Teachers in both groups were asked to implement curricular units on the same topics in physical science and to follow their district science sequence and pacing guide.

## Curricular Context: Intervention Group

Teachers in the intervention group implemented the ASMS curriculum and received professional learning provided by the Lawrence Hall of Science developers. The curriculum package includes a digital platform for students and teachers along with physical materials for hands-on activities. Students interact with physical materials and within a digital workspace with access to custom-written science articles, science simulations, and design tools. The lessons follow an instructional sequence meant to build students' proficiencies with NGSS performance expectations over time. Teachers are provided with digital instructional guides and online monitoring and reporting tools that allow them to view summaries of student progress. The professional learning was held at three points during the school year for a total of 24 hours. The professional learning topics included navigation of the online teaching resources, an overview of the Amplify Science approach, and information about teaching the units.

The ASMS units we studied were in physical science and addressed the topics of structure and properties of matter (e.g., phase change, energy, and matter) and chemical reactions. These units engage students in using and applying their knowledge to investigate and explain an anchor phenomenon. For instance, in one curricular unit students investigate the anchor phenomenon of an unknown substance discovered in a community's water supply. Each unit culminates with students constructing a causal explanation of the anchor phenomenon.

## Curricular Context: Comparison Group

Teachers in the comparison group were asked to teach with their regular curriculum materials and participate in science professional learning as they typically would in their districts. The range of enacted curriculum materials varied across schools, but all were focused on NGSS instruction. Teachers in one district used a widely available redesigned curriculum for the NGSS; teachers in another used their own district-developed curriculum to address the NGSS performance expectations; and most of the teachers in the third district used a district-adopted textbook while some used an open-source, project-based NGSS curriculum. For the research reported in this brief, all teachers in the comparison group were asked to implement their regular NGSS instruction on physical science topics relating to structure and properties of matter and chemical reactions.

# Measures

## Student Learning Measure

At the time we were preparing for the study, there were no existing off-the-shelf assessments for the NGSS. Subsequently, the research team developed two assessments for the broader study: one for physical science and one for life science. The physical science assessment was the learning outcome measure of the study reported in this brief. This assessment elicits performance with aspects of NGSS performance expectations related to MS-PS-1, Matter and Its Interactions. The assessment was fair to both groups (DeBarger et al., 2016) and informed by the design work of the Next Generation Science Assessment project (Harris et al., 2019). It includes constructed-response tasks that address aspects of disciplinary core ideas, science and engineering practices, and crosscutting concepts. Science and engineering practices addressed by the tasks include developing and using models; analyzing and interpreting data; and obtaining, evaluating, and communicating information. Crosscutting concepts include patterns, cause and effect, and energy and matter. The paper-and-pencil tasks were contextualized in scenarios presented in a succinct story format with prompts to elicit integrated responses.

Teachers in both groups were requested to administer the assessment to students after completing their instruction of the physical science topics. All collected assessments were randomized and assigned to independent scorers who received extensive training on the rubrics, with one set of assessments used as a training set. Scorers were blinded to students' identities and group. Aside from the training set, over 20 percent of the assessments were scored by two scorers, with checks for reliability. Any disagreements were resolved by a third scorer. Scores on tasks were totaled to get an overall total score for the assessment. After completing the scoring, we examined the psychometric properties of the assessment. The overall reliability of the assessment was 0.788.

## Curriculum Implementation Measures

We developed and employed a weekly online instructional log and an end-of-year survey to investigate teachers' curriculum enactment and instruction in both groups. The log and survey included

- enactment questions that focused on self-reporting of lessons and activities enacted in a given week, modifications made (and reasons why), and successes and challenges encountered with the materials and

- instruction questions that focused on frequency and depth of engaging students with the NGSS dimensions, instructional strategies employed, and instructional successes and challenges.

Teachers in both groups completed the instructional logs on a weekly basis during their instruction on the physical science topics. All teachers were sent an email toward the end of each week with a link to fill out their individual instructional log. The logs were completed online, similar to a typical online survey. Teachers were encouraged to complete the logs within three days of receiving the link.

# Initial Results

## Finding 1: ASMS Had a Significant Positive Impact on Student Learning

To estimate the impact of ASMS curriculum use on student learning outcomes, we compared the posttest scores for students in intervention schools with the posttest scores for students in comparison schools. The analysis used a two-level hierarchical linear regression model (students nested within schools) controlling for school-level and student-level characteristics and students' prior performance on their 6th grade math and ELA state tests.

Results from the initial analysis showed that students in the intervention schools, who were assigned the ASMS curriculum, scored 7.3 percent higher on the assessment than did students in the comparison schools. The results were similar across gender and racial and ethnic groups and for students with different prior math and literacy achievement. The estimated impact was statistically significant ($p < 0.001$) and corresponds to an effect size of 0.36 (Hedges' $g$). An effect size is a common way in education research to quantify the magnitude of the difference between two groups. To put this in perspective, this effect size is equivalent to the average student in the intervention schools improving 14 percentile points (moving from 50th to 64th percentile) relative to the average student in the comparison schools. The results suggest that implementing ASMS had a significant positive impact on student learning in physical science.

## Finding 2: Teachers Had a Positive Experience with ASMS

Teachers in the intervention group and the comparison group were asked to complete an end-of-year survey about their experience teaching physical science. Preliminary survey findings indicate that most teachers in the intervention group had a positive experience in their use of the ASMS curriculum:

- More than 80% agreed that they and their students benefited from using ASMS curriculum materials,
- 88% reported that ASMS supported them in engaging students in science discourse,
- 73% planned to continue using ASMS after the study ended, and
- 54% reported that using ASMS changed the way they taught science.

Teachers in both groups were also asked to complete an instructional log each week regarding their instruction on the physical science topics. Preliminary findings from the logs show that when teaching physical science, teachers in the comparison group spent a greater percentage of instructional time having their students plan and carry out scientific investigations. Teachers in the intervention group, on the other hand, were more likely than comparison teachers to report that they provided students with opportunities to engage in writing about their thinking and reasoning and to communicate their scientific thinking to peers. The analysis of instructional logs is ongoing and will give us greater insight into (a) how teachers in ASMS classrooms used the various features of the curriculum to support their instructional practice and (b) the ways in which instruction may have differed between the two groups.

# Boundaries of the Study

ASMS is a comprehensive science curriculum that covers physical science, life science, and Earth and space science across all the middle grades, 6th through 8th. The full range of curricular units that span the domains are infused with the same pedagogical approach and were developed with the same design principles (Barber et al., 2021). This study focused on topics covered in the physical science curricular units and was conducted in 7th grade classrooms. Though focused on one domain and at one grade level, the study's findings on student learning provide evidence of promise for the overall NGSS-designed curriculum. Importantly, the findings encourage further research on ASMS curriculum implementation and its impact on student learning at other grade levels and within other science domains.

# Conclusions

This section highlights three areas in which this study stands to contribute to increased understanding of the potential of NGSS-designed curriculum for advancing today's vision for science education.

## Determining the "Ingredients" of Successful Curriculum Materials

This study, though relatively small in scale, is among the first experimental studies of NGSS-designed curriculum materials with measures aligned to the *Framework* and NGSS. The results of our analyses show that students in ASMS classrooms outperformed students in the comparison group on an assessment aligned with NGSS performance expectations for physical science. Important to acknowledge is that teachers in the comparison group used a range of curriculum materials that were also intended to help students build toward achieving the same NGSS performance expectations. This is noteworthy because it directs attention toward identifying and examining the "ingredients" of ASMS that may account for differences in learning. Our ongoing analysis of teacher instructional logs and survey responses will help in this endeavor — our aim will be to better understand the nature of teachers' implementation of the ASMS curriculum and the ways in which the curriculum materials support teachers in implementing NGSS instruction.

## Ensuring Science Learning for All Students

The study findings are also important because they provide evidence for the role of NGSS-designed curriculum in promoting the vision of the *Framework* and the NGSS for all students to have access and opportunity for active participation in science. We conducted our study in schools with diverse student populations that included students whose backgrounds have been historically underrepresented in science education and careers. We found that students performed similarly in the study regardless of gender and racial and ethnic backgrounds. This finding is important because curriculum materials for the NGSS need to be developed to support meaningful three-dimensional science learning for a wide range of students.

## Building an Evidence Base for NGSS-Designed Curriculum Materials

The study also draws attention to the indispensible role of evaluation research in building an evidence base for NGSS-designed curricula. The *Framework* and the 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. This vision for learning requires changes in how science curriculum and instruction are conceptualized, supported, and implemented. Put broadly, the results show that curriculum materials designed for NGSS teaching and learning, along with accompanying professional learning, can support educators in creating classroom conditions that will prepare students for next generation science learning. This is important because it highlights that curriculum materials matter for shifting classroom practice toward the vision of the *Framework* and the NGSS.

ASMS is among the first generation of curriculum materials expressly designed for the NGSS. Along with ASMS, other new NGSS-designed materials have recently been made available (e.g., Edelson et al., 2021). As all of these materials become more widely used across different geographic regions and with varying student populations, additional studies at larger scale and with concerted attention to student diversity and equity will be needed. This current and future research work will be critical for ensuring that the vision of the *Framework* and the NGSS is realized for all students.

**Note regarding the independent nature of the study**

This study was conducted independent of Amplify Education, Inc., who is the publisher and distributor of Amplify Science. Developers from the University of California, Berkeley's Lawrence Hall of Science provided the professional learning support that was part of the ASMS curriculum package. The Lawrence Hall of Science also served as a resource and thought partner to the study team on matters related to the curriculum and its design features. All data collection and analysis activities were carried out independently by the study team.

# References

Barber, J., Loper, S., Greenwald, E., & Krakowski, A. (2021). *Science curriculum materials for deep, equitable science learning at scale* [Manuscript submitted for publication]. Lawrence Hall of Science, University of California, Berkeley.

DeBarger, A. H., Penuel, W. R., Harris, C. J., & Kennedy, C. A. (2016). Building an assessment argument to design and use next generation science assessments in efficacy studies of curriculum interventions. *American Journal of Evaluation*, *37*(2), 174–192.

Edelson, D. C., Reiser, B. J., McNeill, K. L., Mohan, A., Novak, M., Mohan L., Affolter, A., McGill, T. A. W., Buck Bracey, Z. E., Deutch Noll, J., Kowalski, S. M., Novak, D., Lo, A. S., Landel, C., Krumm, A., Penuel, W. R., Van Horne, K., González-Howard, M., & Suárez, E. (2021). Developing research-based instructional materials to support large-scale transformation of science teaching and learning: The approach of the OpenSciEd middle school program. *Journal of Science Teacher Education, 32*(7), 780–804.

Harris, C. J., Krajcik, J., Pellegrino, J., & DeBarger, A. H. (2019). Designing knowledge-in-use assessments to promote deeper learning. *Educational Measurement: Issues and Practice, 38*(2), 53–67.

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

National Science Teachers Association. (2016). *NSTA position statement: The Next Generation Science Standards*. https://static.nsta.org/pdfs/PositionStatement_NGSS.pdf

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. National Academies Press.

**Collaborators**

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