EFFICACY

Seeds of Science/ Roots of Reading: A Combined Science and Literacy Program for Grades 2–5

Amplify.

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Seeds of Science/Roots of Reading is an effective curriculum program for Grades 2–5 that offers students the opportunity for intensive engagement with high-level science concepts through multiple modalities (firsthand investigations, student-to-student discussion, reading science texts, and writing). An explicit focus of the curriculum is *disciplinary literacy*, the specialized skills involved in reading, writing, and talking as scientists do. The program involves students in deep forays into learning about the natural world by searching for evidence through firsthand experiences and text in order to construct more and more accurate and complete understandings of the natural world. Students engage in written and oral discourse with the goal of communicating and negotiating evidence-based explanations, and evaluating and revising explanations.

Designed Uses. The *Seeds/Roots* program is designed to be a core science program (able to address all aspects of science proficiency) while simultaneously serving as a supplementary literacy program (focused on reading comprehension, vocabulary development, and fluency as it relates to non-fiction text). Unlike many science programs that claim to integrate literacy, the *Seeds/Roots* program takes on an equivalent number of learning goals in literacy and science, and provides students with explicit instruction, opportunities for practice, and increasing independence in using literacy strategies to make sense of and communicate about the natural world. As such, the *Seeds/Roots* program provides a strong match to both the Common Core Standards for English Language Arts (CCSS-ELA) and the Next Generation Science Standards (NGSS). For example, a third grade class participating in 100 days of the *Seeds/Roots* program would experience multiple exposures and opportunities to practice most of the Grade 3 CCSS-ELA and most of the Grade 3 NGSS.[1] *The Opportunity Equation* recognized the *Seeds/Roots* program 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).

Multi-modal Approach. The *Seeds/Roots* approach provides students with access to every essential concept to be learned in a unit through a range of different learning modalities—what we call the Do-it; Talk-it; Read-it; Write-it approach. For example, in learning about the concept of erosion, students model the process of erosion by shaking hard candies in a jar and observe the candies getting smaller. They read a book about erosion and the natural forces that can cause it. They discuss the risks of building a house on a cliff overlooking the ocean and use a model to enact that possibility. Students create an illustrated storyboard to chronicle the erosion of an ocean cliff. Not only do students engage with an essential concept through multiple modalities, but each encounter provides opportunities for students to apply, deepen, and extend their knowledge of that concept.

Synergistic Approach to Integration. The *Seeds/Roots* approach engages students in using literacy in the service of inquiry science. For example, students predict what objects are attracted to a magnet and test their predictions. Then, in an attempt to understand surprising results, students search for evidence in text

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[1] Specifically, students in Grade 3 would have multiple exposures and opportunities to practice all or part of 75% of the 31 Grade 3 CCSS-ELA standards; as well as multiple exposures and opportunities to practice 93% of the 15 Grade 3 NGSS Science Practices, multiple exposures to 69% of all or part of the 19 Grade 3 NGSS Disciplinary Core Ideas, and multiple exposures to 100% of the 14 Grade 3 NGSS Crosscutting Concepts.

about the metal composition of the objects they tested. Students are driven to read by a specific need to know. Based on this new evidence, students make claims about what sticks to magnets and write explanations incorporating their claims and evidence. This synergistic approach to integrating science and literacy is in contrast to less authentic approaches to integration, in which students conduct firsthand investigations about X, read about X, and then write about X, what we call additive approaches to integration i.e., they simply add on literacy tasks to a science curriculum or vice versa, and do not provide explicit instruction in how to read and write science text (Pearson, Moje, & Greenleaf, 2010).

Broader Practices of Science. Just as inquiry is an essential practice of science, so are practices that involve students in reading science text, writing science text, and engaging in science talk and argumentation (Duschl, Schweingruber, & Shouse, 2007). The *Seeds/Roots* approach engages students in the broader practices of science that involve reading, writing, and discourse, and also in learning how science works, and how scientific knowledge is constructed. An example of the latter is a book students read in the *Light Energy* unit, called, *Why Scientists Disagree?* This book provides students with information about why and how scientists argue, and helps build an understanding of how argumentation and evidence are central to the enterprise of science. This book provides a model for students as they engage in negotiation of their own firsthand findings about how light interacts with various materials.

Evidence of Efficacy. More than 300 teachers and their students have participated in studies to test the efficacy of the *Seeds of Science/Roots of Reading* curriculum units. An independent evaluator, the National Center for Research on Evaluation, Standards and Student Testing (CRESST) at UCLA, has conducted randomized control studies on two of the Grade 2-3 units, one of the Grade 3-4 units, and one of the Grade 4-5 units. Looking across the studies, students using *Seeds of Science/Roots of Reading* curriculum have consistently outperformed students using business-as-usual, content-comparable science units on measures of science understanding and science vocabulary with mixed results for science writing and science reading comprehension (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Duesbury, Werblow & Twyman, 2011; Wang & Herman, 2005). See Table 1 and 2 for a summary of the efficacy studies and their results.

Table 1. Descriptive Information for Four Seeds/Roots Efficacy Studies

Unit	Grade level	Study Year	# classes	Study Location	Comparison group
Shoreline Science	2-3	2004-05	35	21 states	Content-comparable inquiry science unit provided by us
Soil Habitats	2-3	2004-05	23	21 states	Content-comparable inquiry science unit provided by us
Light Energy	3-4	2007-08	94	1 state	Content-comparable business as usual
Planets and Moons	4-5	2008-09	86	10 states	Content-comparable business as usual

Table 2. Notable Effect Sizes of Seeds/Roots Efficacy Studies

	Effect Sizes *Shoreline Science* (Grades 2-3)	Effect Sizes *Soil Habitats* (Grades 2-3)	Effect Sizes *Light Energy* (Grades 3-4)	Effect Sizes *Planets & Moons* (Grades 4-5)
Science Understanding	.484**	.843**	.65**	.21*
Science Vocabulary	.34**	.41**	.34**	.38**
Science Writing	not measured	not measured	.40**	--
Science Reading	.58*	.51*	--	--

**p<.01; *p<.05;

Focus on English language learners. We have focused significant research and evaluation efforts towards better understanding and building an effective approach that maximizes the effectiveness of the program with English language learners. Based on these studies, there is growing evidence that the *Seeds of Science/Roots of Reading* model of instruction provides English language learners with greater access to science knowledge than typical science programs, helps English language learners develop academic language, and changes the nature of classrooms using the curriculum.

Evidence showing equivalent gains for English language learners and their English-speaking counterparts. In the CRESST efficacy study focused on Grade 2-3 *Seeds/Roots* units, over 1/3 of the 89 classrooms had at least 30% English language learners. The English language learners in that study made equivalent gains on all science measures and most literacy measures to their English-speaking counterparts (Wang & Herman, 2005).

Evidence showing the effectiveness of the program with English language learners. In a small, 10-classroom quasi-experimental study, Bravo and Cervetti (2012) investigated the efficacy of the *Seeds of Science/Roots of Reading* curriculum with English language learners. Ten 5th Grade classrooms, with at least 20% of English language learners, were randomly assigned to either the treatment group (the *Seeds/Roots Planets and Moons* unit), or to their business-as-usual space science unit. English language learners in the *Seeds/Roots* classrooms outperformed English language learners in the comparison condition in science understanding and science vocabulary, but no statistically significant differences were found in science reading.

Interesting qualitative findings from this same study by Bravo, Barber and Cervetti (in an unpublished Final Report to the Noyce Foundation, 2010) also provide evidence for how *Seeds/Roots* classrooms differ from those of the control group. Observations of treatment and control classrooms made during the study point to three revealing impacts of the *Seeds/Roots* materials on classrooms.

- On average, teachers using the *Seeds of Science/Roots of Reading* curriculum devoted 50% more time to science instruction than teachers in the control group.
- In addition, teachers using the *Seeds/Roots* approach seem to be changing the ways they interact with their students: students in *Seeds/Roots* classrooms generally engage in more science-related talk during science sessions.
- More specifically: students in *Seeds/Roots* classrooms engaged in significantly more science-related talk with their peers and with their teachers during science instruction than did students in business as usual classrooms. While correlations such as this can only be suggestive, they provide a basis and direction for future inquiries into the active ingredients of the *Seeds/Roots* approach and how to further magnify the curriculum's impact for ELL students.

This pilot study provides additional evidence that the *Seeds/Roots* model of instruction has advantages for English language learners over more typical approaches to science instruction, and that use of the curriculum appears to change the nature of classrooms by increasing the amount of science-rich talk between students and between students and teachers.

In addition, data from our Grade 4-5 unit efficacy study regarding English language learners were further analyzed by Duesbury, Werblow, and Twyman (2011). They focused on just the English language learners in the study (n=769) and found similar results. Using results from the randomized control design they found that students in the *Seeds/Roots* classrooms outperformed comparison students in the areas of science understanding, understanding of the nature of science, and science vocabulary. For these students, no significant difference was found on tests of science reading and attitudes towards science.

A separate study funded by the National Science Foundation allowed us to follow the pilot work we conducted with a more thorough examination of science-literacy integration for English language learners, in addition to testing the potential of a curriculum design framework (educative curriculum materials) for advancing teacher learning about strategies for supporting linguistically diverse students. The study provides a comparison between teachers randomly assigned to teach a *Seeds/Roots* unit with educative features, or the same unit without educative features. Results demonstrated that teachers who had access to educative curriculum features that described strategies for English language learners used more strategies as they taught the treatment unit and used a wider range of strategies as they taught. In addition, the use of strategies in the treatment classes had a stronger impact on student learning than the use of strategies in the comparison classes, suggesting that the educative curriculum features impacted the quality of strategies that the teachers used. (Cervetti, Billman, & Kulikowich; 2012)

Other independent studies also provide evidence of the promise of the *Seeds of Science/Roots of Reading* approach. Girod & Twyman (2009) found that the *Soil Habitats* unit developed stronger student science conceptual understanding than two inquiry-only units on comparable topics, and demonstrated very positive impact on student understanding of the nature of science and ability to transfer learning to out-of-school settings. Hanauer (2005) documents the effective sequencing of science and literacy instructional routines in the *Shoreline Science* unit through a careful video-analysis of students and teachers engaged in six characteristic lessons in the unit and analysis of resultant student work.

The Program in Use. Our initial expectation for the *Seeds/Roots* program is that schools and districts would adopt it to serve as part (or all) of their core science program AND as a supplement (and or a replacement for part of) their literacy program. This did not turn out as planned due to a variety of factors. First, we found that science and literacy leaders often don‘t talk or coordinate. In fact, it was not uncommon for district science leaders to feel out-of-sorts at the need to coordinate to meet students‘ literacy needs (a common reaction was frustration that even with the literacy-dominated school day, that literacy was to also have a place in science.) Second, there are typically different sources of funding for science and literacy materials and different purchasing cycles for each. There were (and are) district literacy leaders who spoke to us about wanting the program, but for various reasons they could not get the district science leaders on board. The reverse occurred, too. What has unfolded is program use across a fairly broad range of purposes. For instance, we have districts using the program in the following ways:

<u>As simply a better way to teach science.</u> The sites who have brought the program on as "just" a science program were excited by the program‘s research evidence. They recognized that a program that provides students with repeated exposure to ideas through doing, talking, reading, and writing is simply a more robust way to present the science, particularly for lower achieving students.

<u>As a science program that is particularly well-suited for use with English language learners.</u> The evidence we have regarding how the program meets the needs of English language learners has attracted a great deal of attention, and has been the stated reason for adoption of the program in districts that have substantial number of English language learners.

<u>As an intervention literacy program.</u> We have been surprised with the number of places using *Seeds/Roots* in extended day and extended year intervention programs, for students at risk of retention. The program, with its prevalent use of science books and science writing, and explicit instruction of literacy strategies, has proven to provide an engaging context for this "extra" literacy learning. There are three major metropolitan areas using the program in this way as well as lots of smaller situations.

<u>As an English language development program.</u> There are a handful of places that have modified the program for use in their English language development programs.

As a supplementary literacy program. Literacy educators in some districts use components of the program to supplement their fiction-heavy basal literacy programs.

As an on-ramp to hands-on science. We are also seeing schools and districts who first purchase the program's student science books, but follow up with purchase of the full program, thus serving as an on-ramp to hands-on science.

As officially part of their science and literacy programs. And yes, there ARE some places using the program in the way we intended the program to be used.

There are several lessons to be learned from these unanticipated use scenarios. One that particularly stands out for us relates to the need to think through the possible paths to program use that a potentially disruptive intervention, like *Seeds/Roots*, can take. When a product or approach requires disruption of existing organizational structures and/or requires collaboration where there is none, the obstacles to implementation can be large. In situations where the activation energy is not great enough to overcome these obstacles, it can be wiser for implementers to choose another way in to the system. As a field, we often land on design goals that relate only to students and teachers, without taking into account the need to design for use within complex educational systems.

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