“We’re Actually Teaching Science!”: A Partnership Approach to Investigating a New Model for Embedding Language in Science

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ABSTRACT: Due to a lack of science instruction and a need to serve an increasing number of students identifying as Emerging Bilingual, one school district in Oregon sought to develop a new method of integrating science and language instruction. In the model, *all* teachers taught science with embedded language instruction, three to four days a week, to every K-5 student, during a specific, dedicated time of the school day. This initiative sought to build science content knowledge and language proficiency simultaneously through science investigations that put language as the integral component to learning. The research was designed in collaboration with a local university as part of a long-term research-practice partnership with the goal to understand, refine, and repeat the initiative using a reflective, triangulated case study approach. The partnership utilized three rounds of teacher surveys, teacher interviews, and quantitative analyses of student science standardized test scores to understand how science investigations could build science content knowledge and language proficiency simultaneously. Results showed that the innovative initiative increased the quantity of science teaching in the district, may have increased students’ science knowledge, but results also showed that improvements to the model are needed.

NAPDS Nine Essentials Addressed: #4: A shared commitment to innovative and reflective practice by all participants

University-district partnerships are abundant; however, they more often occur as *transactional partnerships* where the institutions pursue their own goals without a shared purpose (i.e., preparing future teachers, offering professional development experiences, providing universities with research opportunities) (Coburn et al., 2013). Such partnerships are valuable, but they become even more so when they transcend to *transformational research-practice partnerships (RPPs)*, which has been happening more and more over the past decade. Transformational partnerships focus on shared goals and thus mutual benefits for both researchers and practitioners (Goldstein et al., 2018). Moreover, these partnerships are: “1) long term, 2) focused on problems of practice, 3) committed to mutualism, 4) use intentional strategies to foster partnership, and 5) produce original analyses” (Coburn et al., 2013, p. 2). The limited published research on RPPs has found these RPPs produce promising impacts on K-12 student learning (Coburn & Penuel, 2016), but it can be a challenge to establish such a partnership successfully.

RPPs have gained momentum as a mechanism of meeting the research needs of districts. Then, as the “mutually beneficial” definition denotes, RPPs also meet the research needs of universities, producing important scholarship on complex, meaningful, timely, and relevant topics (Coburn et al., 2013). While partnerships between universities and schools are common, mutually beneficial partnerships that align with an RPP model are still a rarity. The growth in popularity of RPPs is perhaps best exemplified by the recent establishment of an official National Network of Research-Practice Partnerships (NNERPP), and the growth of its member organizations from 17 partnerships in 2016, including the partnership described here, to 46 members in 2020.

With this model in mind, this particular partnership worked together across university and district lines to investigate the district’s new model for teaching science. This innovative model attempted to meet the specific needs of that district’s students, and therefore collecting and analyzing data from those specific students regarding the effectiveness of the model was key to a reflective practice approach. The first step of this work together required the partnership stakeholders to fully unpack the problem of practice together.

Unpacking the Problem of Practice in Partnership

Employment in science, technology, engineering, and math (STEM) occupations in the U.S. has grown 79% since 1990, from 9.7 million jobs to 17.3 million (Pew Research Center, 2018a). These jobs in STEM pay, on average, more than non-STEM jobs for workers who are similarly educated (Pew Research Center, 2018b). For example, someone with a Bachelor's degree working in a STEM-focused position would earn around $76,000 annually, while someone with a Bachelor's degree working in a non-STEM-focused position would earn around $56,000 annually. Similarly, those who earn a STEM-focused college degree (i.e., with a STEM major), also earn more, on average, than those who earn a non-STEM-focused college degree, and this pattern remains consistent whether or not they work in a STEM-focused job (Pew Research Center, 2018b).

Despite the increasing number of jobs and high incentives of pay, those entering STEM careers remain both low and disproportionately White and male (Litzler et al., 2014). Although approximately 69% of people in the U.S. are women and people of color, only 49% of scientists and engineers are women and people of color (Women, Minorities and Persons with Disabilities in Science and Engineering, 2015). Those who identify as Black or Latino are about half as likely as expected to be engaged in engineering, science, and computer programming jobs (Pew Research Center, 2018b). Further, in terms of gender disproportionality, the majority of women in STEM careers are in health-related jobs, making women even less represented in engineering (14%), computer programming (25%), and physical science (39%) (Pew Research Center, 2018a). Some studies have even found that the gender gap in science is actually worsening over time, with women being three times less likely to become scientists (Bidwell, 2014).

This gap in STEM careers can be traced back to college. While numbers of students pursuing STEM college degrees have risen in the last decade, especially since the Great Recession of 2007 to 2009 (Wright, 2017), the overall numbers remain low. Approximately 15% of males and 7% of females who graduated in 2016 earned STEM-focused degrees (Stockwell, 2017). Further, the demographics of these students remained aligned with demographics in the career: disproportionately White and male. Women earn only 32% of undergraduate science degrees (Bidwell, 2014), despite earning 57% of all undergraduate degrees. While 18% of all degrees earned by White students are in STEM fields, these numbers drop to 12% for Black students and 15% for Latinx students (National Center for Education Statistics, 2019). Further, there appears to be an attrition problem: students who begin STEM majors are about 6% more likely to switch to another major than students pursuing other majors (U.S. Department of Education, 2017). Even more worrisome, students identified as Black or Latinx are statistically more likely to switch majors than their White counterparts (Riegle-Crumb et al., 2019). These gaps call for policy and practice changes that can potentially impact the trajectory of students in STEM.

STEM Opportunity Gaps in K-12 Schooling

These disproportionate outcomes in college may be directly linked to students' experiences in their K-12 schooling, including STEM *opportunity gaps* (Bottia et al., 2017). While students are typically required to complete science coursework in high school, the true STEM *pipeline* starts long before, in elementary school, as students' science knowledge as well as students' attitudes toward science act as predictors of later content knowledge (Newell et al., 2015). In response to the lack of students entering STEM careers, the Next Generation Science Standards (NGSS, 2012) have been adopted by states across the nation. This increased focus on improving K-12 science instruction does not appear to have resulted in an increase in the teaching of the subject in elementary schools, however.

Blank's (2013) extensive analysis of the Schools and Staffing Survey (SASS) found that, during the 2007-08 academic year, elementary teachers in Grades 1 to 4 spent, on average, 2.3 hours per week teaching science. This science time allocation was in comparison to 11.7 hours per week teaching English and 5.6 hours per week teaching Math. These estimates show a decline from 2.8, 2.9, 3.0, and 2.9 average hours of science instruction in 1987-88, 1990-91, 1993-94, and 1999-00, respectively. The 2.3 hours average remained constant in the two iterations of the survey following 2001's No Child Left Behind Act (NCLB), which emphasized accountability measures of reading and math specifically.

However, the findings of Blank's (2013) research actually seem large when compared to other studies. Banilower and colleagues (2013) found that only 20% of K-3 elementary teachers teach science most or all days, every week. Instead, 39% of K-3 teachers teach science three or fewer days every week, and 41% teach science some weeks, but not every week. These numbers increased slightly for teachers of Grades 4 to 6, with 35% teaching science all or most days every week, 33% teaching three or fewer days every week, and 32% teaching science some weeks, but not every week. This same study also investigated the number of approximate minutes spent teaching science each day on average and found that teachers of Grades K to 3 spent approximately 19 minutes per day teaching science, and teachers of Grades 4 to 6 spent approximately 24 minutes per day teaching science. In contrast, teachers spent about 85 minutes per day teaching reading and about 58 minutes per day teaching math (Banilower et al., 2013).

These minimal time allocations to science instruction may also stem from the pressure placed on teachers related to standardized testing, specifically in language arts and math. Griffith and Scharmann's (2008) study sought to understand these changes from teachers' perspectives, discovering that 59% of the teachers in their study described a decrease in the amount of science instruction provided to students since NCLB. One teacher summed it up well: "We have been directed to spend more time on math and reading because those are the subjects upon which AYP [Annual Yearly Progress] is based" (p. 39). In other words, math and reading were the tested subjects and therefore the subjects taught. Elementary school science instruction is clearly lacking time and attention.

The Importance of Teaching Science

The STEM opportunity gaps are even more dismal in terms of access to STEM resources and hands-on experiences for students in high-poverty schools (U.S. Department of Education, 2015). Unfortunately, this inherent focus on reading and math is counterintuitive. Research has repeatedly shown that students need background knowledge to improve their reading—the exact concepts that they gain through an emphasis on teaching science. Recht and Leslie's (1988) seminal study measuring the effects of background knowledge regarding baseball found poor readers with in-depth background knowledge actually outperformed good readers with poor background knowledge on tests of comprehension. A follow-up study with preschool students 25 years later confirmed these findings: gaps in reading comprehension that existed when reading about birds, a topic that the higher-income students had greater background knowledge, disappeared when the same students read about made-up animals (Kaefer et al., 2015). In response to this finding, the National Science Teaching Association (2018) formally recommended science be considered on equal grounds to the other subjects, and schools should aim for at least 60 minutes of science instruction, every day, every week. Teaching science and improving such background knowledge may, in fact, boost reading scores.

Methods of Solving this Problem

This background leads us to the specific problem of practice investigated within this particular district-university partnership. Elementary education faces a plethora of challenges when trying to overcome the problem of *not* teaching science, and this issue was no different in this particular district. Besides the rise of NCLB and the inherent focus on reading and math placed by society, blame has also fallen teachers' lack of science content knowledge and lack of confidence in teaching science. These issues can be traced to preservice teacher preparation, a need for professional development, an inherent distaste for science by many individuals, as well as teachers' own potentially negative experiences learning science (Berg & Mensah, 2014: Gunning & Mensah, 2011; Lee et al., 2016; Lewis et al., 2014).

There are multiple factors that point to the lack of science instruction being a system problem versus a teacher problem. Systems, like districts or states, must emphasize the importance of teaching science and demonstrate this importance through enacting laws, initiatives, funding, professional development, and training. Iowa, for example, sought to promote STEM interest and achievement across the state by convening key state leaders on the Governor's STEM Advisory Council. They have seen associated increases in standardized test scores in math, reading, and science in the years since (ACT, 2017). Even NGSS (2016) has a potential solution, recommending *bundling* science standards together with Common Core (CCSS) math and English Language Arts (ELA) standards to solve the time problem (i.e., there are only so many instructional minutes in the day to "cover everything").

One method of "bundling" (i.e., Next Generation Science Standards, 2016) involves targeting new language standards in many states to meet the needs of growing numbers of students who are emerging bilinguals (EBs), an asset-based term used in place of the traditional English language learner term schools (García, 2009). Students identified as EB are the fastest growing preK-12 student group in the United States, growing 64% from 1994 to 2010 (National Clearinghouse for English Language Acquisition, 2011). As of 2010, out of nearly 50 million students in the U.S., 10% were identified as EB. The percentage of these students who achieve proficiency on statewide assessments is 20 to 30 percentage points lower than among their non-EB peers (Abedi & Dietel, 2004; Hemphill & Vanneman, 2011), indicating a need to address language instructional methods.

Students identifying as EB are challenged with concurrently learning a new language and grade-level content taught in that language. Traditionally, the two tasks are separated; however, researchers have discovered that combining the two can improve students' acquisition of English without losing subject area content (Echevarria et al., 2006; Lee et al., 2013). This research is coupled with shifts in many states to new, EB-specific standards (i.e., in 2013 Oregon adopted new English Language Proficiency Standards (ELPS)). The standards highlight the critical language, knowledge about language, and skills necessary for students to be successful with academic content.

Whereas previous standards focused on grammatical forms and functions separate from other academic content, these new standards focus on learning English through the language needed to participate in academic contexts (Shafer-Wilner, 2013). Because these shifts have all occurred in the last five years, little research has been conducted on how best to meet the needs of students under the colliding influences of NGSS, ELPS, and increasing numbers of students identifying as EB. This challenge is of particular interest in Oregon due to the state having one of the lowest national averages of science instructional hours per week; in Grade 4 it was 1.9 hours per week (Blank, 2013). The district-university RPP allowed for a new model of teaching science within one district to be explored in depth, with the university providing data analysis and reports for the district of the efficacy of this innovative language-embedded science teaching model.

Purpose of this Study

Considering this confluence of events, this one partner school district in Oregon sought to develop a new method of integrating science and language instruction, termed here as Language-Embedded Science (LES). In this district, 40% of the student population were identified as EB, with over 60 different languages spoken; therefore, this method of bundling NGSS with language and the new language standards appeared to be beneficial for students. This district dedicated time for and held the expectation that all teachers would teach science with embedded language instruction three to four days a week, to every student in the elementary school, K-5. Their LES model sought to build science content knowledge and language skills simultaneously through science investigations that emphasized language as the integral component to the learning. There is a dearth of empirical research that examines the impacts of innovative instructional models that integrate language with science content. Therefore, the collaborative partnership determined that the purpose of this study would be to explore the first-year effects of LES, both as perceived by teachers and as evidenced by student test scores, in order to make instructional improvement decisions and determine the program's effectiveness on the district's students.

Methodology

This research study was conducted within one district-university research-practice partnership (RPP). In this particular RPP, the school district and the university collaborated in what sought to be a *transformational partnership* with common goals and mutual benefits (Butcher et al., 2011). The school district and the university worked together to determine the research questions and research design to focus on this problem of practice, desiring that the outcomes produced would positively impact the district's initiative and improve the LES model (Coburn et al., 2013). The partnership stakeholders, which involved district leaders and university faculty, met at least three times annually on a specific schedule, in addition to ad-hoc meetings, to mutually determine the research agenda, design the methodology, disseminate findings, and determine next steps.

Research Design

This case study of an integrated content/language model sought triangulation through multiple sources and perspectives (Merriam, 2009). The perspectives of Merriam (1998) and Miles and Huberman (1994) regarding case study informed this work, wherein "the case as a phenomenon of some sort occurring in a bounded context" (Merriam, 1998, p. 27). In this research, the "case" was the specific LES strategy used by one school district; the "bounded system." All seminal case study researchers agree that case study data must be drawn from multiple sources to fully gain an understanding of the case (Yazan, 2015). To understand LES as a case and its associated effects fully, this triangulated approach involved utilizing three rounds of teacher surveys, teacher interviews, and quantitative analyses of student science standardized test scores.

LES Model

To develop the LES Model, the district went through specific steps. First, a scope and sequence of NGSS standards was developed for each grade level (K-5) using the NGSS topic arrangements (see https://www.nextgenscience.org/topic-arrangement/kforces-and-interactions-pushes-and-pulls for an example). Next, lessons were backward designed employing the 5E method (engage, explore, explain, elaborate, evaluate) and paying particular attention to the inclusion of all three dimensions (Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts). More information can be viewed here: https://ngss.nsta.org/designing-units-and-lessons.aspx. Once the science outcomes were developed, analysis of the student product allowed the curriculum writers, who were teachers on special assignment in the district, to determine the language needs of students to fully participate in a particular lesson's learning. Language need was analyzed based on one of five high leverage language function categories: Describe and Explain, Compare and Contrast, Sequence and Time, Cause and Effect, and Opinion. Once the language function was identified, development of sentence frames (i.e., sentence structures with fill-in-the-blank opportunities to support language learners) to support the chosen language function of each lesson.

Additionally, a multi-tiered system of support method was applied by identifying Tier 1 (i.e., everyday words), Tier 2 (i.e., high frequency words across contexts), and Tier 3 (i.e., low frequency, content-based words) content and function vocabulary. This process then led into inserting high leverage interactive strategies, which gave students multiple opportunities to practice the language and science content of the lesson while matching the content objectives. When needed, direct language form lessons were inserted to develop student understanding of the English grammatical form prior to using the form in the scientific content.

A *walk to science* model was next established in each school to allow the implementation of these lessons. This is an instructional model in which students were divided among classroom teachers and EB teachers, which reduced class sizes through the influx of additional teachers and allowed EB teachers to specifically teach English forms and functions through the content of science. This division of students allowed *all* students to receive greater attention to their individual needs. In some cases, the class size was less than half the class size for other content instruction.

Finally, the district also embedded this LES instructional model into its continuous improvement efforts. As teachers implemented the LES units, they provided feedback on specific lesson components, which were utilized by the lesson writers to improve the units. In addition, the research described here in partnership between the district and university (i.e., the RPP) was also designed to make larger, initiative-wide improvements based on the findings presented here.

Teacher Surveys

The first piece of data collected was teacher surveys at three time points across the first year of implementation of LES. This data collection was conducted in this manner to investigate any changes in perceptions during the implementation year.

Table 1. Demographics of Survey Participants

	Beginning of the Year: December (N = 51)	Middle of the Year: February (N = 86)	End of the Year: June (N = 55)
Grade Level Taught			
Kindergarten	6 (12%)	10 (11%)	3 (5%)
Grade 1	7 (14%)	16 (18%)	11 (20%)
Grade 2	8 (16%)	9 (10%)	6 (11%)
Grade 3	9 (18%)	16 (18%)	10 (18%)
Grade 4	11 (22%)	12 (14%)	7 (13%)
Grade 5	4 (8%)	12 (14%)	4 (7%)
Grade 6	3 (6%)	6 (7%)	3 (5%)
Multi-Grade (EB)	8 (16%)	14 (16%)	11 (20%)
Total	51 (100%)	88 (100%)	55 (100%)

Note. There were approximately 115 teachers who could were invited to participate in each survey round.

Participants. All teachers in the district were asked to complete a survey after implementing the first LES unit in December ($n = 51$), after implementing the second LES unit in February ($n = 86$), and after implementing the fourth and final LES unit in June ($n = 55$). The district employs approximately 115 K-5 teachers, so the response rates across the three time periods were 44%, 75%, and 48% for the beginning, middle, and end of the year, respectively. The survey respondents were fairly well distributed across the grade levels and represented EB teachers as well (see Table 1).

Survey items. The majority of the Likert items on the surveys repeated at least twice across the three time periods. Example survey items included *I like to teach science, My students' science knowledge has improved because of LES,* and *I would recommend LES to teach NGSS*. All items utilized a five-point scale ranging from strongly disagree (1) to strongly agree (5). The surveys also included opportunities for participants to elaborate on their responses in open-ended questions such as, *What support do you need to be successful implementing this new model? How is implementing LES a change from what you were doing before?* and *Is there anything else we need to know about implementing LES?*

Teacher Interviews

The second piece of data collected was teacher interviews, which were conducted at the conclusion of the first year of implementation of LES. These interviews were intended to enhance the data collected from the teacher surveys and to dive deeper into understanding the phenomenon of LES implementation with more qualitative data.

Participants. To provide as much insight on the LES phenomenon as possible, maximum variation sampling techniques were utilized to purposefully select interview participants (Patton, 1990). Because a variety of different perspectives were desired, participants were chosen who both represented distinctly different types of teachers and, within those groups, held distinctly different perspectives on the phenomenon. The final sample of interview participants included 25 teachers in varying roles: 6 teachers on special assignment who were writing and teaching the LES units, 1 district-wide EB coach, 6 EB teachers, and 12 K-5 classroom teachers. Except for the district-wide EB coach, all participants taught LES to students. The 12 K-5 classroom teachers were purposefully chosen to span the grade levels, and included five Kindergarten teachers, two Grade 2 teachers, one Grade 4 teacher, and four Grade 5 teachers.

Interview questions. Example interview items included: *How, if at all, is teaching LES a change from how you taught science last year? How, if at all, has implementing LES affected your students?* and *What, if anything, about implementing LES has been challenging to you?* Interview questions were slightly differentiated depending upon the interviewee's role; the unit writers, for example, were also asked *What lessons have you learned that you would share with other implementers?* Semi-structured interviews were then conducted with the 25 identified teachers in-person, at their school site. Interviews were conducted near the end of the school year (i.e., during April, May, and June), and occurred before school, during lunch, during prep periods, or after school. Each lasted, on average, 20 minutes, depending upon the time that was available and the interest of the participant. Interview lengths ranged from 7 minutes to 36 minutes. All interviews were audiotaped and later transcribed prior to analysis.

Science Test Scores

Lastly, to further investigate the phenomenon, three years of fifth grade science standardized assessment data were analyzed to gain a better understanding of student outcomes in science.

Participants. The fifth grade science standardized assessment test was taken by 523 fifth grade students in 2014-15, 519 fifth grade students in 2015-16, and 562 fifth grade students in 2016-17, the first year of implementation of LES.

Assessment. In Oregon, through 2018 and at the time of this study, the Oregon Assessment of Knowledge and Skills (OAKS) was utilized, and all students in Grade 5 were required to take the science assessment. Science is also tested in Grade 8 and Grade 11, but these results were outside the scope of this study. Although Oregon formally adopted NGSS in 2014, the OAKS science assessment was aligned to the Oregon science content standards adopted in 2009. Because those content standards were aligned with the National Science Standards, there was some alignment but not complete alignment to the new NGSS, which were being taught in LES. Therefore, these results should be interpreted cautiously, as the content being tested was not specifically aligned to the content being taught in LES. The development of the OAKS science assessment generally followed best measurement practices, including item development, content review, sensitivity review, expert review, and field testing (Oregon Department of Education, 2018).

Data Analysis

Qualitative data gathered from open-ended survey questions and teacher interviews was analyzed using a constant comparative approach (Glaser & Strauss, 1967) of dominant emergent themes. Constant comparison data chunks were coded according to overarching commonalities illustrated in the data. Analysis of the data was done using an iterative process of pattern coding (Miles & Huberman, 1994) to look for themes, patterns, and codes to form a 'thick description' of the instructional model (Geertz, 1973). Data were double-coded to ensure reliability. Quantitative data were analyzed using descriptive statistics, independent samples *t*-tests, and one-way analyses of variance (ANOVA). Qualitative survey and interview data were then integrated with quantitative survey and test score data to triangulate themes and patterns.

Results

Several important themes arose from the data, which the district-university partnership unpacked together for formative decision-making. These themes included an increase in instructional science time, an apparent enjoyment by teachers for science teaching, student engagement in the content, and apparent academic improvements in science testing.

We're Teaching Science!

The first clear theme was that prior to the adoption of LES, elementary teachers in the district had not been teaching formalized science, which the district had already hypothesized prior to the launch of the initiative. On the beginning of the year survey, 25 of the 51 responders (50%) described unprompted in the open-ended comments that they were teaching science more than they had been before. One emphasized this with our theme: "We are actually teaching science!" Other survey completers mentioned, "We were not teaching science before," "I'm teaching science consistently," and "Before we tried to include science wherever it fit, but now we have a set schedule to teach the NGSS." In the interviews, one teacher described how "we weren't teaching science K-6 in any sort of sequential way," while another teacher took a historical perspective: "there hasn't been anything in the 12 years I've been here that was science for this grade; it wasn't consistent." Another teacher even described how they did not have "the priority from the district that [teaching science] was a good use of time," while another described how, "in the past we would teach GLAD units irregularly, and when we had EB pull-out it felt like there wasn't enough time in the day to teach science."

Besides simply spending an increased number of instructional minutes each day on science, the teacher participants also described how teaching science was only made possible because lessons were designed for them: "The thing I like about LES is that all these units are already written. It's the first time ever I've had something handed to me that was already written instead of us reinventing the wheel and spicing it up to add engagement." One interviewee really dove into this idea:

> I really appreciate it because I feel it is a cohesive plan for science and for EB which is really helpful for me. I wouldn't be able to teach science, nearly as many units, without having a system in place, and I really appreciate that the district is the one that came up with it because I really feel its tailor made for the students. I also really appreciate that the teachers that developed it have a really good sense of how to teach so I feel like it influences the rest of my day to help me be a little bit more thoughtful about using learning targets and giving kids a chance to discuss things in some ways I hadn't done in the past.

Another teacher spoke to appreciating the lessons were made for the district's specific students:

> I think the program is absolutely unique in that our peers are creating the curriculum. I've never heard of that happening ever; we're always handed curriculum made by a business, which has a different agenda, so this is absolutely ground breaking. Not only that piece that it's being created and constructed by our peers but we have an immediate feedback loop available to us and they're making adjustments in real time for the next unit. Who does that? Nobody! I think it's amazing.

It was clear from both the survey participants and the interview participants that simply mandating teaching science or carving out the time would not have been enough; these teachers needed "personalized" resources to help them bring the mandate to reality.

. . .And We Like Teaching Science!

In addition to the inclusion of science instruction in the school day, many of the teachers also seemed genuinely excited about the new opportunity to teach inquiry-based, hands-on science to smaller class sizes: "It has been really great to make the class sizes smaller for science, more hands-on happens." These smaller class sizes were made possible due to the "walk to LES" model in which EB teachers also taught language-embedded science

Table 2. Teacher Survey Results Regarding Liking to Teach Science from Pre to Post

	Time	n	M *(SD)*	*Disagree*	*Neutral*	*Agree*
I like to teach science.	Pre (December)	51	4.02 (0.88)	8%	14%	78%
EB Teachers		8	4.13 (0.64)	0%	13%	88%
Classroom Teachers		43	4.00 (0.93)	9%	14%	77%
I like to teach science.	Post (June)	55	4.07 (0.90)	2%	31%	67%
EB Teachers		11	4.00 (0.89)	0%	36%	64%
Classroom Teachers		44	4.09 (0.91)	2%	30%	68%

Note. Survey response options ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). There were approximately 115 teachers who could were invited to participate in each survey round.

classes. Even those teachers who were not in love with the district change described this positive exposure: "Kids are getting exposed to science whereas they weren't getting any science before. They like the science; the kids are excited about it." A fifth grade teacher who was "a little skeptical of the whole idea of LES at the beginning of the year" had changed their tune by the end of the year: "Now that I've taught it, I like it. I like that we're incorporating science. I like how I don't have a half an hour where some kids leave the room and we're just filling time with the kids left behind. So, I like that there's a purposeful block of time set aside for science because we've been missing that in our schedule a lot."

In addition to teachers enjoying science, many participants described how the students were also engaged with the content. One EB teacher described how students' "minds were just exploding!" during a space unit that described how the moon orbits the earth, the earth orbits the sun, and the solar system orbits the galactic center. Another fifth grade teacher described how: "I think they're enjoying science more. They're counting on it and looking forward to it. So that's a change. In their year-end letter where they write about next year to the kids with the things to look forward to, science was one of the things they looked forward to!"

This theme was consistent across most of the interviews and was, at least to some extent, triangulated by the survey data (see Table 2), showing the average participant agreed that they liked to teach science throughout the year. While the percent of teachers disagreeing with this statement declined across the year, the percent of teachers agreeing with this statement also declined across the year. These data were disaggregated by teacher type of classroom teachers versus EB teachers; there were no statistically significant differences ($p > .05$) between the type of teacher in enjoyment of teaching science. This disaggregation should be interpreted cautiously due to low response rates, the small sample of EB teachers, as well as the fact that the samples of teachers were not consistently the same teachers completing the surveys; the number of participants for each of the three surveys varied.

And it Seems LES Has Helped Students!

Besides the teachers reporting they liked teaching science, the teachers also perceived that their students' science knowledge had improved because of LES, and these beliefs increased from mid implementation in February to end of implementation in June. For example, 67% of teachers agreed that their students' science knowledge had increased in February, and 75% agreed that their students' science knowledge had increased by June, a statistically significant increase ($p < .05$). There were no differences in strengths of beliefs between EB teachers and classroom teachers (see Table 3).

To triangulate these findings, an analysis of the potential benefits of implementing LES were also revealed through investigating the science standardized test scores, which are taken each year by fifth-grade students statewide. A one-way analysis of variance was utilized to understand the changes over time, and revealed statistically significant differences across the three years, $F(2,1601) = 5.353$, $p = .005$. Tukey post-hoc tests revealed that students receiving LES in 2016-2017 significantly outperformed students not receiving LES in 2015-2016, $p = .004$, but not in 2014-2015. While these results are not definitive, they become clearer when percent meeting bench-

Table 3. Teacher Survey Results Regarding Students' Science Knowledge Improving

	Time	n	M *(SD)*	*Disagree*	*Neutral*	*Agree*
My students' science knowledge has improved because of LES.	Mid (February)	88	3.83 (0.98)	9%	23%	67%
EB Teachers		14	3.93 (0.83)	0%	36%	64%
Classroom Teachers		74	3.81 (1.02)	11%	21%	68%
My students' science knowledge has improved because of LES.	Post (June)	55	3.91 (0.99)	5%	20%	75%
EB Teachers		11	4.09 (0.83)	0%	27%	73%
Classroom Teachers		44	3.86 (1.03)	7%	18%	75%

Note. Survey response options ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). There were approximately 115 teachers who could were invited to participate in each survey round.

Table 4. Fifth Grade OAKS Science Standardized Test Results

		5th Grade Science Standardized Test Score		
Year	n	M	SD	*Percent Passing*
2014-2015	523	222.26	8.50	33%
2015-2016	519	221.05	10.18	35%
2016-2017	562	222.93*	9.75	42%*

Note. *$p < .05$.

mark is analyzed, which ranged from 33% to 35% in the two years prior to implementing LES, while scores increased significantly ($p = .01$) to 42% meeting benchmark during the LES implementation year. It appears that fifth grade students' science knowledge may have increased because of the new LES program implementation (see Table 4). These measurements of knowledge should continue to be monitored as students who are taking this test continue to receive more years of science instruction through LES, and as the standardized test transitions to be a measure of the NGSS standards that were taught versus the previous Oregon standards. Further, it is important to remember that these are different groups of students, and therefore may have scored differently without the implementation of LES.

These results were further disaggregated through a two-way analysis of variance (ANOVA) to understand the effects by school. The results for 2014-2015 and 2015-2016 were very consistent from school to school, therefore these two scores were averaged and then the growth from 2016-2017 over the average 2014-2015 and 2015-2016 score was tabulated. The results revealed a significant effect by year ($p < .001$), by school ($p < .001$), and an interaction effect of year by school ($p < .001$). Three of the schools saw increases in percent of students passing of 11%, 17%, and 19% more students passing in the LES implementation year. Because of these findings, future research within the partnership plans to examine if fidelity of implementation was a factor in students' science knowledge growth.

But There is Much Improvement to be Made

Despite the positive academic results and participant feedback, LES was no magic bullet, and was not appreciated by all participants. Besides the recommendations by participants to make LES stronger, of which the list was quite exhaustive, there were also those who did not support the initiative at all. As an example, one survey participant noted, "As both a science and language program, it was severely inadequate although some students have gained a bit more familiarity with science concepts," while another said, "I do not agree with the model and all the student needs it tries to meet at the same time." Some classroom teachers were "wary of being the sole provider of language instruction," and others even felt like this model was "a disservice to EB students because [the classroom teachers] aren't EB teachers." Similarly, and somewhat surprising given some of the previously discussed themes, the survey participants did not generally recommend LES to teach NGSS (see Table 5). For example, only 43% of teachers agreed in February that they would recommend LES to teach NGSS, and only 45% agreed in June that they would recommend LES to teach NGSS. While these differences were not statistically significant by teacher type, a pattern does seem to emerge, where EB teachers appeared slightly less likely to recommend LES.

Three clear themes arose about how this model could be improved, as suggested by research participants. First, many participants described a need for transparency from the district about *how* and *why* the LES model was implemented. It is likely that this type of work by the district might improve the roughly one-third of teachers who simply disagreed (see Table 5) that they would recommend the model to teach science. This group who simply did not like the LES model, may need convincing that change can be good.

Second, it is clear that, as with any first-year initiative, there is a need to continue to revise and improve the lessons, units, and model over time. While this revision process was already incorporated into the overall three-year plan of the roll-out of LES, the importance and need for revision cannot be underestimated. This theme arose from nearly every single interview and survey. Teachers appreciated that "the lessons are really scaffolded, the fact that we have pictures already made and they're in color is really helpful," and agreed that "the topics have been great," yet many mentioned that "the quality of the LES units has varied significantly, which has been frustrating." Because the district built in a feedback loop for each teacher to provide feedback after implementing each unit (which is the source of much of the data for this study), and the team of curriculum writers had dedicated time to work on these

Table 5. Teacher Survey Results Regarding Recommending LES to Teach NGSS

	Time	n	M *(SD)*	*Disagree*	*Neutral*	*Agree*
I would recommend LES to teach NGSS.	Mid (February)	88	3.04 (1.33)	31%	26%	43%
EB Teachers		14	3.07 (1.07)	14%	57%	29%
Classroom Teachers		74	3.03 (1.38)	35%	19%	46%
I would recommend LES to teach NGSS.	Post (June)	55	3.06 (1.33)	35%	20%	45%
EB Teachers		11	2.73 (1.42)	45%	18%	36%
Classroom Teachers		44	3.14 (1.31)	32%	20%	48%

Note. NGSS = Next Generation Science Standards. Survey response options ranged from 1 (Strongly Disagree) to 5 (Strongly Agree).

revisions, many of these recommendations and issues may be eliminated in the second year of implementation.

Third, a description of a need for more professional development (PD) arose again and again, from a variety of perspectives and on a variety of topics. The overarching request, however, was: "We need training on inquiry-based instruction because it's different than what we've done before, and then how to incorporate the English instruction throughout your whole day is really where we need to head, because that was really the intent of this." Participants described how implementing the new NGSS standards was difficult enough without layering the language aspect on top. Some described wanting to hear from a true NGSS expert: "Bring in an outside resource around this because this is new for the state in general, so it would be nice to have somebody there that's been in the NGSS world longer than any of us." It was clear that classroom teachers also needed and wanted PD on embedding language in instruction in general: "We want more PD so I can support language instruction throughout the day." These critiques could help implementation and development of the LES model.

Discussion

This district-university RPP investigation revealed some important findings, both for the partnership to pursue and the wider audience. Integrated language with science may be one answer to our current dilemmas of not meeting the needs of students identified as EB (Hemphill & Vanneman, 2011) and the promotion of science instruction that emphasizes learning through local contexts and rich language (NGSS, 2013). The results of this case study are promising: it appears that this LES method may be one way to increase the quantity and standards-based quality of science teaching in elementary schools in this particular district. Students appeared to increase their science knowledge, both in terms of Grade 5 test scores and as perceived by teachers.

At the same time, the results of this study were not all positive. The polarity of the results of this study indicate the complexity of this issue. These mixed results may be because language intensive practices rely heavily on academic discourse to develop both student science content and language knowledge. To make this model successful, teachers need to be generally familiar with procedures that develop rich classroom discourse (Thompson et al., 2013). This type of ambitious teaching requires teachers to have sufficient science content knowledge in order to teach it to students using inquiry-based practices (Kolbe & Jorgenson, 2018). After all, Kolbe and Jorgenson found that teachers with the least science content knowledge also implemented inquiry-based practices the least. Beyond this, implementing the NGSS is difficult and complex, and, "achieving this new vision will require time, resources, and ongoing commitment from state, district, and school leaders, as well as classroom teachers" (National Research Council, 2015, p. 1).

It is possible that PD is one of the essential ingredients to improvement in elementary science instruction that also intentionally supports students identified as EB. This theme was mentioned repeatedly in the interviews and surveys. The science test scores, while increasing, were low overall, which also could be an indicator that increased PD could be beneficial. Teachers: "need training on inquiry-based instruction because it's different than what we've done before, and then how to incorporate language instruction throughout the whole day." This participant comment suggests the need to support teacher learning through PD that expands teacher academic experiences to discursive strategies that support EBs (González-Howard et al., 2015).

Additionally, there is a need to examine how teachers work through issues of coherence of previous beliefs and new learning, which can impact the effectiveness of PD and instruction (Allen & Penuel, 2015). One study found that only 59% of elementary teachers had received *any* science-focused professional development in the last three years (Banilower et al., 2013). By contrast, 87% of elementary teachers had received math-focused professional development in the past three years. Further, only 21% of elementary teachers reported that the science-focused professional development they received gave heavy emphasis to *Teaching science to English-language learners*.

This finding reveals an important implication for this particular RPP. RPPs focus on mutually beneficial activities but more primarily in the research realm. While producing district-driven research results to inform and impact education is the partnership's top priority, with an aim at collaborative reflection regarding innovative practice (i.e., the fourth essential of the National Association for Professional Development Schools; 2020), perhaps RPPs need to consider merging with Professional Development Schools in some way as models for providing this needed professional development (i.e., Darling-Hammond, 1994). What we know about effective professional development that impacts student achievement is that it is not easy, cheap, nor quick (Gore et al., 2017; Yoon et al., 2007). To overcome this barrier, perhaps RPPs could capitalize on already formed research relationships to merge them with already formed district-university partnerships to support student teaching to provide professional development needed by teachers in situations such as to support the adoption of LES in this study. The third of nine "required essentials" stated by the National Association for Professional Development Schools (NAPDS; 2020) requires "Ongoing and reciprocal professional development for all participants guided by need," (para. 7) and well sums up the next-step needs for this particular study conducted in partnership.

Conclusion

In sum, more research is needed in integrated science and language instruction that specifically supports emergent bilinguals. This one pilot study conducted within one RPP helps to fill a research gap, and yet this study only focused on the first year of implementation of a new initiative, and more research is needed. Although the triangulation across multiple data sources (i.e., three teacher surveys of 50 or more teachers each time, interviews with 25 different teachers, and an analysis of student test scores of over 500 students each year) increased trustworthiness of the study, this study lacked consistent teachers and students across the analyzed time points and would benefit from increased teacher response rates. Further, these findings must be tracked over time, as initiatives and changes like these take years to experience sustained effects, requiring *transformation* (Hayward, 2010). One teacher participant even described this, hoping that the district would not abandon the endeavor:

> I just hope that they continue to make it a priority. . . I am concerned they're going to hear all the negativity and decide to drop it because it's too much trouble, so that's sad to me because I really feel like it's a great opportunity for kids to work on their language development and be able to do science.

Change is complex and takes time (Fullan, 2007). The district, and the partnership as a whole, plan to stay the course. SUP

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