A Two-year Randomized Literacy-integrated Science Intervention with Middle School low-SES Spanish-speaking English Learners and English Speakers

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Project MSSELL

- Project Middle School Science for English Language Learners (MSSELL) is a collaborative research project between Texas A&M University and Sam Houston State University, funded by the National Science Foundation.

- Goal – evaluate, via a quasi-experimental design, the effectiveness of a literacy-integrated science intervention on fifth grade low-SES ELLs’ and non-ELLs’ science and reading literacy achievement on accountability-based state assessments and standardized language measures.
Research Questions

• Do students who are enrolled in the literacy-embedded science treatment condition classrooms perform better on the district science benchmark tests, and state standardized science test than do students in a comparison condition for low-SES ELLs and non-ELLs, respectively?

• Do students who are enrolled in the literacy-embedded science treatment condition classrooms perform better on the district reading benchmark tests, and state standardized reading test than do students in a comparison condition for low-SES ELLs and non-ELLs, respectively?

• Do students who are enrolled in the literacy-embedded science treatment condition classrooms perform better on the standardized English measure than do students in a comparison condition for low-SES ELLs and non-ELLs, respectively?
Introduction

• Learning scientific language is an integral part of science learning (Norris & Phillips, 2003) and instruction should include explicit learning of science language for all students (Wellington & Osborne, 2001).

• Scientific language often presents a barrier to many students’ science learning, because it is composed of distinctive linguistic features and unfamiliar discourse patterns fundamentally different from the everyday language that most students use in general context (Fang, 2005; Gee, 2005).

• Reading proficiency is considered to be the foundation for school success, because the learning of content knowledge is mediated by level of academic language skills (Greenleaf et al., 2011; Kieffer, Lesaux, Rivera, & Francis, 2009).
Introduction

• The amount of language-based activities is significantly reduced especially in secondary science classrooms due to teachers’ lack of knowledge on how to integrate literacy instruction into hands-on scientific exploration (Author, 2012; Greenleaf et al., 2011; Rivard, 2004).

• Advanced literacy instruction should be embedded within content area classes as a focus for middle and high school settings (Shanahan & Shanahan, 2008; Stoddart, Pinal, Latzke, & Canaday, 2002).

• Students of color, who come from low socio-economic status (SES) backgrounds, and who are English language learners (ELLs) may be at a significant disadvantage in science and reading (National Center for Education Statistics [NCES], 2012 a, b).
Achievement Gap in Science and Reading

- In eighth grade, Hispanic and African American students scored 27 and 34 points below White students in science on NAEP 2011 assessment (NCES, 2012a).

- Low-SES students scored 27 points below students non-eligible for the lunch program in both fourth and eighth grade (NCES, 2012a).

- ELLs scored 43 points below English-speaking students (NCES, 2010) in reading.

- The percentage of ELLs at or above proficient at eighth grade level was 2% in science, as compared to 32% among English-speaking students (NCES, 2010).
Inquiry-based interventions have been found to promote the development of ELLs’ conceptual understanding of science (August et al., 2009; Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Lee et al., 2008).

Geier et al. (2008) examined the effect of a combination of standards-based and inquiry science instruction on standardized science achievement in an urban school district. It was reported that seventh and eighth graders receiving standards-based science inquiry intervention outperformed their peers in science content and process understanding.
Inquiry-based approach for low-SES students

• In urban classrooms, including those classrooms of diverse students and those who are poor, the use of science inquiry in the classroom has been demonstrated to be successful (Cuevas, Lee, Hart, & Deaktor, 2005; Marx et al., 2004; Seiler 2001; Warren et al., 2001).

• Thadani, Cook, Griffis, Wise, and Blakey (2010) addressed the equity issues among low-SES and language minority students through curriculum-based interventions in science education. Learning benefits were found for intervention students at the schools applied inquiry-based science interventions.
Without the explicit learning of science language, science will simply “remain a foreign language to most students” (Wellington & Osborne, 2001, p. 139), especially for ELLs.

Watkins and Lindahl (2010) recommended that a structured reading framework in science can and should include the use of explicit vocabulary instruction for ELLs in the content areas. They provided a useful framework of strategies to activate student background knowledge, increase student motivation and reading comprehension, and integrate vocabulary, oral, and written language development within content area instruction.
Literacy Integration in Science

• Science curriculum that integrates content learning and literacy development can promote reading skills, and, not surprisingly, science content knowledge for low SES diverse students (Connor et al., 2010; Fang & Wei, 2010).

• Inquiry-based science plus reading (ISR, Fang & Wei, 2010)

Infusion with explicit reading instruction and a weekly-based home science reading program ➔ more effective inquiry-based science than the science-only curriculum
Aldine ISD Demographics

- 69.7% Hispanic
- 25.9% African American
- 85.1% Economically Disadvantaged
- 31.2% ELL
- 24.7% Mobility Rate

(Texas Education Agency, 2012)
Research Design

<table>
<thead>
<tr>
<th>5th</th>
<th>6th</th>
<th>English Language Learners (ELLs)</th>
<th>Non-ELLs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science Enhanced Program (SEP)</td>
<td>2 schools 3 teachers 6 rotations 206 total students 164 permits</td>
<td>2 schools 2 teachers 5 rotations 84 total students 69 permits</td>
</tr>
<tr>
<td></td>
<td>Science Typical Program (STP)</td>
<td>2 schools 3 teachers 6 rotations 171 total students 77 permits</td>
<td>2 schools 6 teachers 12 rotations 246 total students 102 permits</td>
</tr>
</tbody>
</table>

Experimental - at school level
Quasi Experimental - at student level
Trained Paraprofessionals

Four Dimensional Bilingual Pedagogical Theory

Family Involvement

Collaborations with Scientists

Science Engagement Strategies

Oral Academic Language

Four Dimensional Bilingual Pedagogical Theory

Classroom Observations using Instrument for Bilingual/ESL Classroom Pedagogy

Two Levels / Three Tiered Approach

District / University Leadership & Support

Integrated Structured English as Second Language Strategies in Science

Increased focus & time

Curriculum Alignment, Scaffolded Lessons, and Benchmark Assessments

Targeted Vocabulary, Writing, and Reading Techniques

Questioning Methods

Technology-Integrated Teaching Strategies

Ongoing Staff Development, Reflection, and Feedback

Trained Paraprofessionals = Science Tutorials
Two Levels, Three Tiers

Level I
Teacher Professional Development

Level II
Student Instructional Intervention

Tier 1
District curriculum taught in all content areas, except in science

Tier 2
Academic science intervention components

Tier 3
Tutorials for lowest achieving students
Science Intervention – Level I
Teacher Professional Development

• Systematic and structured training, monitoring, mentoring, feedback, and self-assessment through reflection via professional portfolio

• Bi-weekly staff development sessions:
  – English science vocabulary building and fluency
  – Oral and written academic science language development
  – Integrated science content reading comprehension
  – Imbedded ESL strategies in science
  – Enhanced instruction for science teaching
    - 5E Instructional Model
    - Questioning strategies

• Monthly staff development for paraprofessionals
Teacher Training
Two Levels, Three Tiers

Level I
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Level II: Student Instructional Intervention

- Tier 1: District curriculum taught in all content areas, except science
Two Levels, Three Tiers

Level I
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Science Intervention Level II: Student Instructional Intervention

- Academic in-class science intervention (85 minutes daily) using 5E Model of instruction (Bybee et al., 2006):
  - Engage: make connections between past and present learning, focus students’ thinking
  - Explore: provides students with common base of experience through manipulating materials or exploring environment
  - Explain: students verbalize understandings, teachers introduce formal definitions, explanations for concepts
  - Elaborate: students develop deeper and broader understandings by practicing skills or learning more information
  - Evaluate: students and teachers evaluate understandings of concepts
Level II:
Student Instructional Intervention

- Integrated curriculum components:
Science Intervention – Level II
CRISELLA
Content Area Reading in Science for English Literacy and Language Acquisition

• Supporting science and reading skills with expository (informative) text:
  – Vocabulary development and extensions
  – Word reading instruction
  – Partner reading
  – Using text from Scott Foresman ©2010 series and ScienceSaurus that directly align to 5th grade science TEKS (Texas Essential Knowledge and Skills, state guidelines)
Science Intervention – Level II
WAVES
Written and Academic oral language
Vocabulary development in English in Science

- Individual science notebooks to help students process science content by:
  - Predicting
  - Recording
  - Organizing
  - Drawing
  - Questioning
  - Reflecting
WAVES

1. Two - series circuits
2. Water
3. Waves

Questions:

1. What is the answer to B because?
2. How does light move through glass?
TIELLAS
Technology Integration for English Language and Literacy Acquisition in Science

• Technology integrated into intervention:
  – Equipping classrooms with instructional technology (ELMO document camera, projector, Mimio interactive white-board, science learning tools)
  – Integration of science educational software (EduSmart)
  – Exploring internet science resources to support learning
  – Suggesting related websites in Family Involvement in Science take-home books
Teacher uses document camera to demonstrate magnetism.
Technology Integration

Students learn about kinetic energy while viewing EduSmart.
Earth’s Changing Surface (Rapid)

**Science Objectives:**
- Day 1 (Monday) – The student will describe how an earthquake can change the surface of Earth using a foldable.
- Day 2 (Tuesday) – The student will identify and describe how forces can change the surface of Earth using a news report.
- Day 3 (Wednesday) – The student will describe how forces can change the surface of Earth using a foldable.
- Day 4 (Thursday) – The student will interpret how land forms are the result of constructive forces using a foldable.
- Day 5 (Friday) – The student will interpret how land forms are the result of destructive forces using a foldable.

**Reading Objectives:**
- The student understands explicit ideas and information in fifth-grade or higher texts (for example, main idea, implied message, relevant supporting details and facts, chronological order of events).
- The student uses simple strategies to determine meaning and increase vocabulary for reading, including the use of prefixes, suffixes, root words, multiple meanings, antonyms, synonyms, and word relationships.

**ESL Strategies:** Academic Language Scaffolding, Cooperative Learning, Leveled Questions, Modeled Talk, Think Aloud, Visual Scaffolding

**TEKS:**
- Science: 3.6B, 5.12A, Process Skills
- Language Arts: 5.4A, 5.5F, 5.6A, 5.7A, 5.8B, 5.9B, 5.9E, 5.10A, 5.10G, 5.10L, 5.11B, 5.13B, 5.15A
- ELPS: 1A, 1E, 2C, 3D, 4A, 4J, 5B

**Target Vocabulary:**
Verbs: identify, interpret
Content: force, constructive force, destructive force, earthquake, volcano, tsunami, landslide, flood, glacier, weathering erosion, deposition of sediment

**Materials:**
- **Warm-Up:** Forces that change the Earth’s surface ½ sheet, pocket folders
- **Engage:** W20D1.ppt
- **Explore:** fault boxes for demonstration
- **Explain:** EduSmart 3.6B #1 & 2, Week 20 Vocabulary.ppt, SF Textbook p. 268-269, Partner Reading Discussion Card W20D1
- **Evaluate:** Earthquake foldable template, journal
- **Copy of Week 20 homework**
Daily Activities

Day 1: 83 minutes

DOWLS: Forces that change the surface of Earth [Pocket Folders] (7 – 10 minutes)
Each student receives a half sheet for warm-up.
Display warm-up on ELMO.
Read prompt with the students. Students explain how they decided which forces change the surface of Earth quickly. Let students discuss their answers with their group. Call on students randomly to share their answers.

*Have students change and add answers as you review the warm-up with the class.

Engage: Power point – Earthquake (5 minutes)

Have students observe the slides. Discuss with students that earthquakes not only damage and destroy buildings, but they also change the surface of Earth.

Questions:  
Describe the damage to buildings by the force of the earthquake.  
Describe the damage to the surface of the Earth by the force of the earthquake.  
Draw a conclusion about the force of earthquakes.

Call on students to share their responses.

Refer to the objective for the day.

Identify the cognitive verb for today.  
What does it mean to describe?

Explore: Fault boxes - model (15 minutes)

Have students observe the fault boxes when they are together. Shift the boxes.
Have students observe power point slides. Discuss slides with the students.
Questions: Describe how the earthquake changed the surface of Earth. Explain how this model is different than a real earthquake. Explain why we use models.

Explain: EduSmart 3.6.B #1 & #2 and Textbook 268-269

EduSmart – Glaciers (15 minutes)
Students will view this section of EduSmart. At each section break, ask the appropriate questions using the questioning strategies.

CRISSELLA
Vocabulary Preview [Power Point] (4 minutes)
Show students Week 20 Vocabulary powerpoint slides 1-5, stop where designated

Textbook p. 268-269 – Earthquakes (6 minutes)
Set timer for 4 minutes as students partner-read the selection. Partners will read the discussion questions on the Partner Reading Discussion Card and then re-read the selection a second time, looking for the answers. After re-reading, partners will discuss answers.
Define earthquake.
Define fault.
Identify the cause of earthquakes.
Describe the effects of earthquakes.

Evaluate / Product: Notebook Foldable – Earthquake [Journal] (20 minutes)

Foldable – Students will identify earthquakes as a force that can change the surface of Earth. Students will describe how an earthquake can change the surface of Earth.

Explain to the students they are creating a foldable to show their knowledge of the causes and effects of earthquakes. This is the assessment for today. Students need to work on foldable individually.

Review power point with students before they begin to work on the product.

Closure: (3 minutes)
Identify the force that can cause land to rise or fall down.
Identify the cause of earthquakes.
Identify the effects of earthquakes.
Explain why we do not have earthquakes in Texas.

Homework: (5 minutes) Briefly preview weekly homework.
Level II: Student Instructional Intervention

- Integrated curriculum components:
Scientists as Role Models and Mentors

• Mentoring program involving science professors and graduate students
  – Assist with teaching specific science topics
  – Science Saturdays at Sam
    • students visit Sam Houston State University science labs and are mentored on various science topics
Science Saturdays at Sam

Students investigate the strength of a Madagascar Hissing Cockroach.
Students investigate surface tension while creating art.
Students investigate revolution.
Students investigate crustal deformation.
Science Saturdays at Sam

Students explore seed germination.
FIS
Family Involvement in Science

- Take-home science materials developed for students to work with parents/family
- Provides family members with opportunities to conduct science activities and become citizen scientists
- Materials in both English and Spanish
  - Materials lists
  - Safety information
  - Reference reading materials
- Families are offered a 45-minute session on how to implement FIS at home
Dear Family,

Your child is learning about forces in motion. We are learning how to describe motion and to measure and record the position and direction of an object’s motion. We are looking at a simple machine, the bicycle, to learn about the kinds of forces that cause motion, such as gravity and friction.

Your child is also learning many new vocabulary words that describe forces. Help your child to make these words a part of his or her own vocabulary by using them when you talk together about the forces you see and use every day.

<table>
<thead>
<tr>
<th>WORD</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>measure</td>
<td>to find the size, amount, capacity, or degree of something</td>
</tr>
<tr>
<td>record</td>
<td>to make a written note, to put in writing</td>
</tr>
<tr>
<td>direction</td>
<td>the line or course something follows or points to</td>
</tr>
<tr>
<td>force</td>
<td>a push or pull that acts on an object</td>
</tr>
<tr>
<td>friction</td>
<td>a force between two surfaces rubbing against each other</td>
</tr>
<tr>
<td>motion</td>
<td>change in an object’s position; movement</td>
</tr>
<tr>
<td>gravity</td>
<td>the force that pulls objects toward each other</td>
</tr>
<tr>
<td>pendulum</td>
<td>a weight hung, as in a clock, so that it can swing in a back and forth motion</td>
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</tbody>
</table>

The following pages include activities that you and your child can do together. By participating in your child’s education, you will help to bring the learning home.
Family Science Activity

Balancing Ball

Try this experiment at home with a family member. It shows the force of air pressure.

Materials:
- a hair dryer (blower)
- a ping pong ball

Steps:

a. Hold the hair dryer so it blows a stream of air straight up.

b. Carefully balance the ball above the airstream.

c. Now, pull the ball slowly out of the flow. Notice that when only half the ball is out of the airstream, you can feel it being sucked back in.

d. Let go of the ball and notice that it hovers back and forth and then settles down near the center of the airstream.

Talk About It

When the ball is suspended, the air flowing upward hits the bottom of the ball and slows down, generating a region of higher pressure. The high-pressure region of air under the ball holds the ball up against the pull of gravity.

When you pull the ball partially out of the airstream, the air flows around the curve of the ball and then continues outward above the ball. This outward-flowing air exerts an inward force on the ball, just like the downward flow of air beneath a helicopter exerts an upward force on the blades of the helicopter. This force is what makes the ball feel like it is getting sucked back in.
Project MSSELL

Family Involvement in Science
Two Levels, Three Tiers

Level I
Teacher Professional Development

Level II
Student Instructional Intervention

Tier I
District curriculum taught in all content areas, except in science

Tier 2
Academic science intervention components

Tier 3
Tutorials for lowest achieving students
Level II: Student Instructional Intervention

• Tier 3: Additional tutorials provided by teachers and trained paraprofessionals for lowest achieving students:
  – **MSSELL-X** (Middle School Science for English Language Learners – eXtra)
    • Daily tutoring focusing on science concepts, science vocabulary, oracy, and writing development
Fidelity

- Inter-rater reliability .86
- Quantitative check based on a 4-point Likert rating scale based on each of the 5-E, with a total possible score of 124, mean = 107.17

(a) material usage and material preparation (b) student involvement, (c) academic language scaffolding, (d) affective and cognitive feedback, (e) writing feedback, and (f) pacing
The Control/Typical Practice of Science Instruction

- 80-90 minutes daily
- taught by certified or permitted bilingual/ESL education and science education teachers.
- a locally-developed science curriculum aligned to the state standards.
- 5-E model once per week
- varied ESL strategies and teachers’ questions strategies
- limited use of science journals.
Measures

• State standardized test: 5th grade Texas Assessment of Knowledge and Skills (TAKS) in science

• District benchmark tests in science—5th and 6th grade, cumulative of physics, chemistry, space, earth and life science, with process skills integrated

• Curriculum-based assessment -6th grade pre- and post-test

• District benchmark tests in reading—5th and 6th grade

• Dynamic Indicators of Basic Literacy Skills (DIBELS)—Oral Reading Fluency

• Woodcock Language Proficiency Battery-Revised (WLPB-R)—Verbal Analogies ($\alpha = .83$), Oral Vocabulary ($\alpha = .78$), Passage Comprehension ($\alpha = .83$), 5th-6th grade
District Benchmark Science Test

- Over the two years:
  ELLs: treatment > control peers (passing rate) on 4 out of 5 tests in grade 5, and 5 out of 6 tests in grade 6 with a median effect size (Cramer's V) of .235;

  Non-ELLs: treatment > control on 4 out of 5 tests in grade 5, and all 6 tests in grade 6 with a median effect size of .201.

- More importantly, the difference was more evident in 6th grade as compared to 5th grade between treatment and control ELLs.
Science Benchmark-ELLs
5th Grade

Test 1
Test 2
Test 3
Test 4
Test 6

Treatment
Control
Science Benchmark-ELLs
6th Grade

Test 1  Test 2  Test 3  Test 4  Test 5  Test 6

Treatment  Control
Science Benchmark-non-ELLs
5th Grade

Test 1  Test 2  Test 3  Test 4  Test 6

Treatment  Control
6th grade science assessments

- Treatment students outperformed control students on post-test after pre-test performance is adjusted, with an effect size (partial eta squared) of .083 for non-ELLs, and .294 for ELLs.
• Over the two years:
  ELLs: treatment > control (passing rate) on 3 out of 4 tests in grade 5, and 2 out of 4 in grade 6 (average Cramer's V = .145);

  Non-ELLs: treatment > control on 3 out of 4 tests in grade 5, and 2 out of 4 in grade 6 with a median effect size of .093.
Reading Benchmark-ELLs 5th Grade

- Test 1
- Test 2
- Test 4
- Test 6

Legend:
- Blue: Treatment
- Red: Control
Reading Benchmark-non-ELLs 5th Grade

Test 1  Test 2  Test 4  Test 6

Treatment  Control
Reading Benchmark-non-ELLs 6th Grade

- Test 1
- Test 2
- Test 3
- Test 4

Treatments and Control groups compared across tests.
ELLs: Students in the treatment condition achieved higher gains from pre-test to post-test;

Non-ELLs: no difference was identified.
Oral Vocabulary - ELLs

Scale Score

Beginning of 5th grade  |  End of 5th grade  |  End of 6th grade

Control  |  Treatment
Discussion

• Students receiving **literacy-embedded science intervention** from fifth to sixth grade outperformed those who did not receive the intervention in the following areas:
  
  • Reading comprehension
  
  • Knowledge of word meanings
  
  • Mastery of science concepts comparable to grade level
  
  • High academic science and reading achievements that are considerably above the state standards
Discussion

• building science vocabulary by teaching roots, stems, prefixes
• teaching students how to decode multi-syllable science words
• introducing definitions and pronunciation of new science words
• bridging past and present learning in science
• setting aside time for partner-reading of expository science text; and
• asking leveled comprehension questions with higher order leveled questions being placed strategically in the lesson and being asked with more frequency than lower order questions.
Discussion

• Inquiry approaches to teaching and learning science, rather than teaching strategies in high needs schools in an attempt to raise test scores, can promote students’ performance on standardized and high-stakes achievement tests (e.g. August, Branum-Martin, Cardenas-Hagan, & Francis, 2009; Cuevas et al., 2005; Lee et al., 2008).

• Even a modest amount of literacy integration in science instruction can promote students’ scientific literacy (Fang & Wei, 2010).

• “Science learning entails and benefits from embedded literacy activities...” (Pearson, Moje, & Greenleaf, 2010, p. 462).
Conclusion and Recommendation

- Literature shows that the lower level of science literacy at the beginning of 8th grade, the more slowly the students will progress from 8th to 12th grade (Muller, Stage, & Kinzie, 2001).

- Our intervention provides an opportunity for low-SES ethnic minority students, both ELLs and non-ELLs, to acquire more science knowledge and skills so as to potentially remove initial difference when they mature to 8th grade to compete with their middle-class White peers.
Conclusion and Recommendation

• The advantage of our intervention is that it can be implemented in schools by enhancing and modifying traditional practice, provided that the teachers are given quality professional development on content-area strategies and time to develop their skills.

• If school district personnel introduce nonintrusive, consistent, yet structured literacy-integrated science interventions with supported professional development, then teachers may be open to such practices to improve minority students’ academic English proficiency and science achievement.
Conclusion and Recommendation

• Our intervention makes an important contribution to the field in that little is known as whether the enhanced practice that makes effective for ELLs also makes it effective for low SES fluent English speaking students of color, because these two groups of students are often placed in the same classroom.

• Future studies should focus on the quality of science instruction from which low-SES students can benefit.
Contact Information

• http://www.ldn.tamu.edu