SCIENCE VOCABULARY SUPPORT (SVS)
PROGRAM DEVELOPMENT, REFINEMENT, AND PRELIMINARY EFFECTIVENESS EVALUATION

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Study setting

Newcomer Academy

- To enroll:
  - Year 1 in the U.S
  - Score ≤ 2 “Beginner” on the district’s English proficiency test (range 1-6; WIDA)
  - Middle/high school-aged (12-21)

- Sheltered instruction school for Grades 6-11 newcomers
  - 25 primary languages
  - ≈ 75% refugees
  - ≈ 25% limited or interrupted formal schooling

- **High School** (Grade 9-11)
Background: Student need

• Both teachers and students identify technical, specialized vocabulary as one of the biggest challenges for newcomers (Brown et al., 2006; Miller, 2009):
  
  [S1] “Language like scientific terms this is really giving me a problem and I don’t do well in science.”

  [S2] “I like Biology and I was the best in my class in my home country but now here it is difficult for me. The language is difficult.” (Brown et al., 2006; p. 157)

• Research indicates that vocabulary is a strong predictor of reading comprehension and standardized assessment performance (Cisco & Padrón, 2012)
Science Vocabulary & Research Gaps

• “The heavy use of scientific terminology to explain concepts [. . . ] raises the readability level of science textbooks” (Harmon et al., 2005, p. 271)
  
  • technical vocabulary, concept-loaded words (‘photosynthesis’)

  • nontechnical words, not concept-loaded words (‘component’; Hwang et al. 2014; Lawrence et al. 2012; Lesaux et al., 2014)

  • signals or procedural vocabulary, words linking concept-loaded (‘be the result of’; Macken-Horarik 2002; Richardson Bruna et al., 2007)

• Research on specialized, technical vocabulary of science—particularly when it comes to low-literacy bilingual ELs—remains limited (Tong et al., 2014; Miller, 2009)
Study objectives

1. To examine current vocabulary literature to identify effective, research-based vocabulary instruction principles, practices, and routines;

2. To develop the *Science Vocabulary Support (SVS)* program—focused on science + general academic vocabulary—suitable to the learning needs of newcomer high school ELs;

3. To refine the program based on teacher feedback and student performance; and

4. To conduct a preliminary investigation of the program effectiveness
SVS Development: Research-based practices and principles

- Vocabulary selection criteria
- Instructional principles, practices, routines
- Curricular materials
Vocabulary selection

  - 76-page chapter
  - normally allocated 12-14 weeks of instruction
  - supplemented with a *Science Words* feature (new words bolded and defined both on a sidebar and in the glossary)

- Targeted vocabulary selection was conducted in close collaboration with the teacher and proceeded in two steps.
Step 1: Science vocabulary difficulty categorization schema adopted from Miller’s (2009)

<table>
<thead>
<tr>
<th>Vocabulary Category</th>
<th>Examples</th>
<th>Comprehension Problem Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-scientific enabling words (directions)</td>
<td><strong>Opposite</strong>, backward, rearward, forward, parallel, horizontal, vertical</td>
<td>New vocabulary</td>
</tr>
<tr>
<td>Scientific processes/descriptions of motion</td>
<td>At rest, <strong>constant speed</strong>, <strong>accelerate</strong> (acceleration), <strong>decelerate</strong> (deceleration), push, pull, cause to move (to accelerate/decelerate), <strong>increase</strong>, <strong>decrease</strong></td>
<td>Scientific specificity + new vocabulary</td>
</tr>
<tr>
<td>Conceptual phrases</td>
<td>Apply (applied) force, active (acting) force, <strong>exert a force</strong>, <strong>experience a force</strong>, source of the force</td>
<td>Concept, scientific specificity</td>
</tr>
<tr>
<td>Measurements</td>
<td>Meter per second, time interval, unit of acceleration, <strong>number</strong>, <strong>amount</strong>, 1.0 N</td>
<td>Concept, complexity</td>
</tr>
</tbody>
</table>
Step 2: Wilson’s (1998) science vocabulary selection criteria

1. Is the word necessary for students’ initial understanding of a particular scientific concept?
2. Will the term add to a student’s ability to link related concepts?
Example of selected words

Science specific words
- friction
- gravity
- inertia
- de/acceleration

Enabling words
- action
- amount
- in/decrease
- opposite
SVS programs’ guiding principles

Based on “powerful vocabulary instruction” theory and research (Nagy, 1988), the SVS program is guided by 3 principles:

1. **Integration**: to facilitate learning, instructed words and ideas need to be linked with other knowledge

2. **Repetition**: multiple exposures to the targeted words are needed to facilitate word learning and application

3. **Meaningful Use**: contextual use of the instructed words
SVS instructional practices

- Contextualization & decontextualization
- Focus on form
- Focus on meaning
- Predictable routines
- Teaching of learning strategies
- Negotiation
SVS Learning Cycle

• The SVS program targets **10 words per week**
  • 6 new words + 4 review words from previous weeks

Target words:
• introduced through direct instruction on Monday
• incorporated in daily 5-15 minute Monday-through-Friday word study activities

Word study activities:
• rotate in a consistent fashion across each day of the week
• include games (e.g., picture match, definition match, charades, jeopardy)
• writing activities (e.g., spelling pyramid, sentence generation, quizzes)
<table>
<thead>
<tr>
<th>Day</th>
<th>Word Study Routines</th>
<th>Science Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>- Teacher introduces new words in mini-scenarios</td>
<td>- S &amp; L objectives</td>
</tr>
<tr>
<td></td>
<td>- Whole-class discussion of related words/parts</td>
<td>- Short background videos</td>
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<tr>
<td></td>
<td>- Students enter word, definition, picture/graphic</td>
<td>- Chapter preview</td>
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<tr>
<td></td>
<td>- Students discuss terms in pairs (L1)</td>
<td></td>
</tr>
<tr>
<td>Tu</td>
<td>- Picture Match (words + pictures)</td>
<td>- Science Journaling</td>
</tr>
<tr>
<td></td>
<td>- HW: (a) spelling pyramid &amp; (b) sentence generation</td>
<td>(SJ): Procedures</td>
</tr>
<tr>
<td>W</td>
<td>- Card game (words + definitions)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Written homework assignment review</td>
<td>- Science investigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- SJ: Observations</td>
</tr>
<tr>
<td>Th</td>
<td>- Team games (Charades OR Jeopardy)</td>
<td>SJ: Report writing</td>
</tr>
<tr>
<td>Fr</td>
<td>Cloze exercise (quiz): Students match targeted words to sentences</td>
<td>Extension: Videos, extra chapter activities</td>
</tr>
</tbody>
</table>

SJ: Science Journaling
SVS Curricular Components

Student set of weekly activities:
- word and picture cards for games and assignments

Weekly teacher Power Point:
- an individual slide per each new word for the Monday introduction
- directions for the Monday-through-Friday activities

Vocabulary Journal, a set of graphic organizers for each new word with space for (Marzano & Pickering, 2005):
- the term
- its definition
- graphic representation,
- additional information
Procedures & data sources

SVS implementation:
• Six weeks (October - January 2012-2013)

Program development and effectiveness evaluation was informed by three approaches:
a) situated ethnographic qualitative approach
b) weekly vocabulary quizzes
c) a pre-post design pilot study
Participants

Students - enrolled in four Grade 9-10 classrooms
- $N \approx 92$
- 51% female
- $M_{\text{age}} = 15.9$ (range: 14-19)
- English proficiency ranged from ‘entering’ to ‘beginning.’

Science teacher + ESL endorsement
- a Caucasian male with 15 years of teaching experience
- 5 years in the Newcomer Academy
Qualitative data collection

- grounded in the authentic practice of the teacher
- featured ongoing, extensive researcher-teacher collaboration
  - weekly curriculum materials development communications
  - classroom observations
  - post-instruction conversations and reflections
  - ongoing informal conversations

- semi-structured interviews
  - current practices and challenges (pre)
  - perceptions of the program impact (post)
Qualitative Results (pre-SVS)

• Teaching philosophy:
  • “a good way for the teacher is to step back and let the kids interact with the words a little bit”

• Teaching strategies:
  • students’ copying the day’s agenda (+ vocabulary)
  • using Cornell notes (two columns: words + meanings)
  • a student-generated glossary for their self-created books
  • word wall
  • teacher’s using images or acting out meanings of terms

4 “typical” of content-area teaching instances of new vocabulary use, namely: “in [...] teaching; the textbook; the class notes; and in talking to students” (Miller 2009, 588).
Weekly Vocabulary Quizzes

- A word-sentence-match format (8 words: 6-8 new + 2-0 review)
  
  Example item: *We say that a car is __________ when it is going faster and faster* (solution: *accelerating*).

- Task format = ‘cloze’ or a ‘word fill-in’ task
  
  - concurrent validity (correlations SAT verbal: .36 -.65; Cohen, 2012)
  - internal reliability (alpha reliability range: .77–.86; Lesaux et al., 2010)
Weekly Vocabulary Quizzes: Results

An average increase of 23%
- **Total**: 65% to 88%
- **Grade 9**: 53% to 84%
- **Grade 10**: 77% to 91%
Pre-Post Pilot: *Science Vocabulary Measure*

- Two tasks (Beck & McKeown, 2007; Townsend & Collins, 2009):
  - **picture**, selecting a corresponding targeted word from a set of four (4 items; *a format that, in essence, allows to test 16 words*; Nation, 1983)
  - **verbal**, matching vocabulary with definitions (6 items)
- Scored as $0 = \text{incorrect}$ or $1 = \text{correct}$
- Raw scores were converted into % correct
- Reliability: .67 (pre) and .68 (post)
Science Vocabulary Measure: Descriptive statistics, *t*-test results, and effect sizes

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>$t(60)$</th>
<th>$d$ [95%CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Total</td>
<td>57.54</td>
<td>25.34</td>
<td>72.30</td>
<td>24.86</td>
</tr>
<tr>
<td>Verbal</td>
<td>57.93</td>
<td>31.27</td>
<td>71.58</td>
<td>31.53</td>
</tr>
<tr>
<td>Picture</td>
<td>56.97</td>
<td>28.19</td>
<td>73.36</td>
<td>26.17</td>
</tr>
</tbody>
</table>

*Note.* $N = 61$. All *t*-tests are significant at $p < .005$. 
Qualitative Results (post-SVS)

• SVS benefits:
  • **structured, intentional revisiting of targeted words:** “frontloading, revisiting the same words again in the context of science-centric instruction; and revisiting again” using different modalities such as pictures, acting out
  • **teaching language tailored to specific science instruction:** “allows my students to access prior knowledge and express what they are learning.”

Summary statement: “I feel confident my students can better express what they learned.”
Study significance

• Merit of specifically targeting science-specific, technical vocabulary for instructional interventions

• Demonstrate the effectiveness of research-based vocabulary development strategies with a new population of high school newcomer ELs
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