Science Language Use by Kindergartners: Strategies That Support English as an Additional Language Learners

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Introduction

The purpose of this study was to examine the effectiveness of combining strategies targeted to English as an Additional Language (EAL) students with an inquiry approach modified for kindergartners. Seventeen students (EAL n=9) explored magnets through an inquiry investigation and used pictures to make predictions about the magnetic attraction of eight items; tested, and then recorded their observations. Predictions were compared to observations as an indicator of learning. Teacher instruction and students' conversations were videotaped and transcribed. Dialogue was examined to determine the frequency of scientific language use. Three students demonstrated learning gain and no student recorded more than one observed item incorrectly. Science language was used by all but one student. Of the 242 science words counted, students whose primary language is English used a total of 157, while EAL students used a total of 85. Students demonstrated learning about magnetism in spite of marked differences in language use.

This study examined the effectiveness of implementing strategies designed for students who are adding English to their linguistic repertoire. To depict the kindergarten participants in this study, the following referent "English as an Additional Language (EAL)" was chosen from the Department for Education and Skills (2006) to emphasize one asset of these emergent bilinguals. The terms "English Language Learner" (ELL) and "English as a Second Language" (ESL) are more commonly used in reference to students whose native language is other than English. Drawing from these definitions (Au, 1998; Crawford & Krashen, 2007; Fitzgerald, 1995), an EAL student is described as "a person born outside of the United States whose native language is not English, [or] an individual who comes from an environment in which English is not dominant" (Mays, 2008, p. 415). This paper also describes the implementation of a modified inquiry approach combined with other EAL strategies to encourage development of academic science language by kindergarten students.

Rationale

If forecasts prove correct, bilinguals will be among those minority groups (ethnic, cultural and socioeconomic) that will constitute over 50% of students in schools in the United States by as early as the first quarter of this century (George, Raphael, & Florio-Ruane, 2003). If current trends continue, one in three students will qualify as an EAL speaker by the end of the first half of this century (Crawford & Krashen, 2007). However, students in these groups are underrepresented in university science programs and scientific careers. The time for science in elementary education is severely limited with students in grades 1 - 4 spending less than 14% of their time exposed to science in schools (National Center for Education Statistics, 1997). The science curriculum is often shelved, taking a back seat to literacy and mathematics instruction, and this is frequently the case in classrooms with high numbers of EAL students (Rosebery, Warren, Conant, & Hudicourt-Barnes, 1992). Few U.S. teachers appear to be equipped to meet the needs of this growing population, with less than 20% fluent in another language, or certified in bilingual or ESL education (Crawford & Krashen, 2007; Martin, 2003).

For EAL students learning English (Corson, 1997; Fisher, Frey, & Rothenberg, 2008) and science in particular (Lemke, 1990; Rivard & Straw, 2000), it is essential to structure opportunities for students to talk about science, practicing their use of academic science language related to the content. The various ways students combine words and thoughts, termed discourse (Gee, 2001), changes throughout the day between home and school. Primary discourse, that which takes place outside of school (i.e., spoken with family and members of the community), is very different from academic discourse which is used in curriculum and assessment. Yet it is the alignment between these discourses that appears to promote students' success in schools (Mays, 2008). It is easy to understand how "the special academic meaning systems of education are more readily entered by people whose experiences outside schools link them directly into the academic 'culture of literacy'" (Corson, 1997, p. 672). However, the disparity between the content of primary and academic discourse is much greater for EAL students compared to mainstream students whose first language is English (Corson, 1997; Mays, 2008). As such, there may be a disadvantage for EAL students compared to mainstream students in developing academic language.

A recent review of the literature suggests that when ELLs are taught in English, there appears to be a direct relationship between their English language proficiency and their learning of science (Lee, 2005). It is essential for science educators to be invested in building students' capacities in both. There is a growing body of literature describing what works to support literacy in the content areas. In a recent, rigorous, quasi-experimental design study in a linguistically diverse population of students, there is evidence that the integration of literacy and inquiry approaches in science have a positive impact on students (Samarapungavan, Mantzicopoulos, & Patrick, 2008). These researchers showed kindergartners learning in integrated classrooms developed a working understanding of biological content such as insect anatomy and life cycle as well as the processes of scientific inquiry, such as prediction, observation, and record keeping. Not surprisingly, their understanding of *inquiry,* including generating questions and making predictions, was better than students in traditional classrooms. The teachers reported being surprised by the rich vocabulary the kindergartners were able to develop through scientific inquiry.

Motivation for the present study stemmed from work supported by a federally funded initiative to improve the educative experiences of EALs. The topic for the reflective study was chosen to inform and enhance revisions of a science methods course for elementary pre-service teachers. The pre-service teachers in this course struggled to differentiate their lessons to meet the needs of EAL students. For the culminating task, pre-service teachers were required to present video-clips of lessons they taught, *showing* how their elementary students used the academic language of science. The stakes were relatively high for these pre-service teachers, as their performance was worth ten percent of their final course grade. While they were generally successful in prompting their classes, the elementary students' responses they captured rarely consisted of more than a few words, and the quality of scientific discourse they were able to promote left much to be desired. This assessment prompted a re-examination of the criteria for the assignment, that is, "how realistic were these expectations?" This pressing question led to the design of the present investigation. Using a case study design, a cooperating teacher for the science methods course was approached with the essential question for this study -- if lessons are intentionally designed with a variety of strategies that are known to support learning of EAL students, how much scientific language expression can be reasonably expected?

In this exploratory study, students' conversations were examined to determine how many science terms they actually used during inquiry-based lessons in which teachers purposefully employed ELL techniques to support all learners. The findings from this case study provide some insight into how effective these strategies are in promoting the use of scientific language and the science content learning that results (i.e., magnetic attraction). A modified inquiry approach, the Science Writing Heuristic (SWH), was chosen for the unit because it was well suited for the topic of magnets. In addition, there is a growing body of research demonstrating positive effects of the approach on students' learning of science concepts (Hand, 2008; Norton-Meier, Hand, Hockenberry, & Wise, 2008). The specific instructional techniques drawn from ELL and ESL literature are described in the following section.

Design

Qualitative methods were used in this descriptive investigation (Lincoln & Guba, 1985). The classroom was intentionally selected for this study based on the composition of students (52% EAL students) and the teacher's reputation as a bilingual educator who regularly utilized a variety of EAL techniques in her lessons.

Prior to the study, the researcher was becoming a familiar presence in the school, having made 35 observations during supervision of student teachers and pre-service teachers enrolled in a science methods course at the university. Prior to beginning the study, the classroom was observed on four separate days. During one of these sessions, the researcher took on the role of a support person in the classroom, interacting with students in an attempt to become even more familiar with the teacher's signals and classroom routines and to encourage student participation in the subsequent science lessons under investigation. In addition, the researcher met with the teacher to discuss the expectations of language use with the SWH inquiry approach (Hand & Keys, 1999) and to ensure that developmentally appropriate modifications were made for all of the kindergarten students, considering the EAL students in particular.

Participants

Seventeen out of 19 kindergarten students were present and able to participate in the study. Of those participating, there were 9 EAL students (6 girls and 3 boys) and 8 native English speakers (2 girls and 6 boys). The majority of EAL students spoke Spanish, and one student spoke Mandarin. Students worked in groups of four during the study due to the absence of two participating students on separate days. The regular classroom teacher organized students into working groups according to achievement and EAL representation. Achievement demarcation of high (H), medium (M) or low (L) was determined from a variety of means, including teacher observations, 6 mathematics assessments (2 per quarter), 3 reading assessments and 3 report cards (quarterly).

Instructional sequence and strategies

For this study, students explored a unit on magnets through an inquiry approach during two 30-minute lessons over 2 days. The unit sequence is outlined in Table 1. While the researcher conducted the lessons, both the teacher and the researcher purposefully utilized strategies that are known to support EAL students' learning (Table 2). The lesson sequence was based on the SWH inquiry approach, although this was highly modified in that rather than writing, the kindergartners communicated by verbalizing and placing labeled pictures on an inquiry task, indicating whether items would be attracted to a magnet or not. Students were encouraged to focus on some of the key elements of inquiry: sharing beginning ideas, exploring materials, making predictions, recording observations and reporting their discoveries.

Table 1. *Outline of the instructional sequence and student arrangement for the magnet unit*

Day	Lesson Component	Arrangement
1	Researcher elicited students' prior knowledge and questions about magnets	Whole class
	Students explored bins of magnets, magnetic, and non-magnetic materials	Table groups
2	Reviewed the terms magnet and metal; introduced observe, test & predict	Whole class
	Students physically demonstrated the interaction they observed between a magnet and a paperclip	Partners
	Researcher demonstrated using two magnets	Whole class
	Researcher explained predict and observe tasks, named each picture	Whole class
	Students recorded predictions	Individually in table groups
	Students tested items and recorded observations	Individually in table .groups
	Students continued exploring magnetic and non-magnetic materials	Table groups
	Students shared discoveries made during explorations	Table groups/ Whole class
	Researcher closed with distinction between items that pull/attract (magnets) and items that respond to magnets by moving (attracted items)	Table groups/ Whole class

Table 2. *List of focus strategies employed during the magnet unit*

	Description of Strategy
A	Eliciting personal knowledge, experience, and beginning ideas about magnets
B	Using choral repetition of terms (e.g., magnet, metal, observe)
C	Spelling science words out together as a group
D	Linking native language to English science terms (e.g., magnet = iman; observe = observar in Spanish), and allowing students the opportunity to identify language similarities
E	Allowing children to use their primary (or native) language
F	Using students' native language (classroom teacher) to explain tasks when clarification was requested
G	Utilizing alternative modes of assessment (e.g., pictures along with English term printed)
H	Working in cooperative groups balanced by EAL and achievement
I	Providing opportunities for students to test their ideas and share discoveries made from explorations
J	Accepting apparently incorrect responses and probing students for reasoning
K	Focusing on basic scientific processes of inquiry (e.g., predicting, testing, and observing)

Note. Superscripts indicate strategy recommendation by the authors (Au, 1998[AG]; Buzzelli, 1996 [DF]; Cox-Petersen & Olson, 2007[G]; Crawford & Krashen, 2007 [DFH]; (Corson, 1997[EH], Delpit, 1988[AE]; Mays, 2008 [ADEFGHJ]; Martin, 2003[EGHK]; Watts-Taffe & Truscott, 2000[J]).

Data collection and analysis

The lessons on both days were videotaped, which included the introductory section conducted by the researcher and all of the interactions during group work. As an indicator of what students were able to do, videotapes were examined to determine students' use of science language. A video camera was positioned at each of the four tables with a Sound Grabber II™ microphone to capture students' verbalizations. Four videotapes, totaling just over three hours of footage, were later transcribed in full. Notes were made on the transcripts focusing on the science terminology used by students. Descriptions pertained to the nature of students' interactions during group work at their tables. The science terms uttered by each student were counted, recorded, and reported as frequencies.

In consideration of the developmental level of kindergarten students participating in this study, the words chosen to count as science terms consisted of actual science terms such as magnet and metal, and scientific inquiry terms including test and observe, as well as students' own descriptive terms used in communicating their observations. These terms included scientific observation terms such as sticks, pulled, and connected. Codes for designating specific scientific vocabulary that was uttered by the students were developed and discussed with an impartial, external examiner. Disagreements as to what constituted a science term for counting were discussed in the context of students' dialogue in the transcripts until consensus was reached.

Data was also collected from student inquiry work for which they recorded their predictions and observations about the response of eight items in relation to magnets (magnetic items: paperclip, chair leg, screw, metal washer; non-magnetic items: leaf, paper, seed, crayon). For the purpose of recording their ideas on this assessment, students used pre-printed pictures of each of the items with their corresponding English word printed below. They glued these pictures under a column with headings, which were also represented in pictures that depicted either magnetic attraction (a magnet touching a paperclip), or lack of magnetic attraction (a magnet a few centimeters from a leaf). Student inquiry work was examined for the correct placement of pictures for all eight items on both the predictions record sheet and the observations record sheet. The researcher introduced the task to the students in a whole group setting, and two items, the paperclip and the leaf, were discussed to illustrate the expectations. Students worked in groups at tables to carry out the task and were encouraged to talk about their ideas while they individually classified the pictures on the sheet. As an indicator of learning, comparisons of the inquiry tasks were made between each student's prediction and observation record.

Findings

Following the exploratory phase on day 1 and an introduction on day 2, students were asked to make predictions, test and record their observations. As a wide variety of items was available during the exploratory phase, it is not surprising that only 3 students made incorrect predictions, one EAL and two native English speakers. These three students demonstrated learning gain from the observations, scoring 100% on the observation sheet. There was one missing picture on one student's data sheet, and even so, no student recorded more than one observation incorrectly. Two EAL students made the same mistake in recording their observations of the eight items, indicating that a magnet can attract paper, although these were not the same students who incorrectly predicted.

Examination of the videotapes offered one possible explanation. A native English speaker was rediscovering what he had learned from a summer session, demonstrating the phenomenon of a magnetic field penetrating paper, which he displayed for his table group with great enthusiasm. This student, the native English speaker, correctly recorded that paper is not attracted to magnets on both his prediction and observation sheets; thus, he was able to realize that the phenomenon he demonstrated was different from what was being asked of him on the assessment (attraction vs. field strength). While he did not have the language to explain the distinction in the captivating phenomenon of a magnetic field, witnessing such a display may have influenced the EAL student at his table to change his idea about the potential for paper to be attracted to a magnet, resulting in a phenomenological misconception. Notably, the other student who incorrectly placed paper as attracted on her observation sheet was sitting at the next table, and may have been similarly influenced.

Table 3. *Frequency (f) of kindergarten student science utterances (by primary language and gender) during a unit on magnets*

Primary Language	Sex	n	Science words (*f*)	*f*/n
English as an Additional Language (EAL)	Girls	6	38	6.33
	Boys	3	47	15.67
English as a First Language	Girls	2	6	3.0
	Boys	6	151	25.17
Total		17	242	

Science language was used by all but one student (8 EAL and 8 primary English speakers). No utterances of science terms were recorded from an EAL girl who had been absent on day 1 when most of the lesson time was available for exploration and student conversation. Of the 242 science words counted (Table 3), students whose primary language is English uttered a total of 157 words, while EAL students spoke a total of 85. Notably, girls whose first language is English spoke the fewest science terms, although this group was also the least represented (n=2). In summary, students were able to demonstrate learning on inquiry tasks in spite of marked differences in scientific language use.

Conclusion and implications

This case study was undertaken to capture kindergarteners' use of science language during lessons on magnets that intentionally incorporated EAL strategies and elements of scientific inquiry. The findings represent one small snapshot of EAL learners and native English speakers. In addressing the essential question, setting high expectations for pre-service teachers to utilize strategies that support development of language is warranted. These high expectations were realistic expectations, as there were multiple opportunities to capture the science language expressed by the young students participating in the unit under study.

Considering it takes approximately five years for EAL learners to learn academic English similar to their mainstream peers (Cummins, 1981), the results are interesting. The enhanced instructional strategies allowed students to attain comparable language use at this early stage of kindergarten. While not every student produced the academic science language of the lesson abundantly or equally, they were able to internalize meaning of a basic science concept of magnetism by correctly responding to verbal prompts and inquiry tasks. Taken together, their performances indicated that all the kindergartners acquired comprehension of the academic language.

Importantly, these findings suggest that it is possible for EAL and mainstream students to demonstrate learning of a basic science concept (magnetic attraction) without verbalizing science terms to a great extent during their explorations. Students who spoke few science terms were likely participating with the language through a variety of means during their explorations with magnets. Experiential modes included listening to the use of academic science language by other students and the teachers, watching one another's "hands-on" displays, and experiencing the phenomena physically. Visual, audial, physical, and verbal interactions appeared to be essential for these students to adopt the meanings and successfully represent their learning about magnets. Results from this case study are in agreement with recommendations that point to the value of providing multiple opportunities for students to engage with the language of science (Fisher et al., 2008; Gee, 2001; Hand, 2008; Keys, 1996; Lemke, 1990; Martin, 1993, Patrick et al., 2009; Rivard & Straw, 2000; Samarapungavan et al., 2008). The results also point to the importance of designing authentic, interactive, inquiry experiences that give students ample time to engage in collaborative dialogue about the science phenomena they witness (Hand, 2008; Patrick et al., 2009; Samarapungavan et al., 2008).

Most of the students responded correctly to the inquiry task at the time they made predictions, likely due to their learning experiences from explorations on the first day. On the observation sheet, three students improved the number of correct responses, indicating a gain in learning about magnets by distinguishing between items that magnets attract and those they do not. While no student recorded more than one item incorrectly from their observations, the interaction between students exploring the strength of a magnetic field suggests that some students may be at an advantage in representing their understanding of phenomena, particularly those that require an intuitive leap in language interpretation. For example, seeing paper "stick" between a magnet and a paperclip may influence a kindergartener to consider paper as being "attracted" to magnets. This suggests there is a need for educators to help students unpack the language of a science concept, drawing students' attention to the features that distinguish between phenomena. Such an extension is critical, even in considering that the related phenomenon may be under the curricular benchmarks covered by teachers in the next grade-level.

For another potentially necessary extension, consider the demonstration of magnetic attraction with two materials. It is not only the "sticking" that constitutes attraction, but also the pulling "action" of the magnet. Students are quickly drawn to the "stick" they see for magnetic objects, collecting masses of magnetic items in a bundle; however, non-magnetic items are often "stuck" within these artistic creations. To draw on their creative exploration, the next step might be to focus on the action of a magnet in isolation with one other item. Students at this developmental stage likely also need more scaffolding to focus their senses on experiencing the "pull." Such extensions may be particularly important after students explore multiple items in kits to prevent introducing misconceptions, as several non-metallic items may appear "stuck" in between a collection of magnets and magnetic items.

The difference in language use between girls and boys (Table 3) warrants further comment. While this is one small case study, in which native English girls were under-represented, collectively, girls used fewer science terms. While these results are not necessarily alarming, because students were able to learn the objectives with varying levels of verbalization, additional research is needed to determine if girls may be at a disadvantage at a very early age. In line with a report focused on the advancement of gender equity, further research on this potentially critical factor is important "to know not only what works but also what works for whom" (American Association of University Women Educational Foundation, 2004, p. 22). In terms of achievement, it appears similar between girls and boys through grade 3, though girls are less confident in their abilities compared to males, and males outperform females in science at the fourth grade level in the U. S. (American Association of University Women Educational Foundation, 2004).

It is commonly accepted that students with different learning styles vary in response to different instructional interventions. Rivard and Straw (2000) found that opportunities for social negotiation through discussion and writing were important for secondary school females. While Andre (1997) found that text-based conceptual change strategies work well for both sexes, the effectiveness of these strategies may depend on additional factors, such as interest and engagement (Chambers & Andre, 1995). In a survey of students' (K-3) attitudes, no differences were found between girls' and boys' perceived ability in science or fondness of science compared to other subjects, though stereotypical differences appeared in older elementary students (Andre, Whigham, Hendrickson, & Chambers, 1999). These researchers found physical science was the least preferred by all students compared to reading, math and life science. This view persisted for girls in upper elementary grades, where boys thought better of their physical science ability than did girls, while girls reported higher abilities in reading than did boys. As the authors suggested, if an aversion to physical science originates in elementary school for females, it points to the need to begin inclusive equity programs early on.

In a separate study, authors found no difference in reports of liking science between kindergarten boys and girls in an integrated inquiry group, and these students felt more competent in their science ability compared to students in traditional classrooms. However, in the traditional classrooms boys reported liking science more than girls (Patrick, Mantzicopoulos, & Samarapungavan, 2009). Considering the research above, and in light of the present study, the recommendation by Andre and others (1999) for early, inclusive interventions are supported. For such programs, literacy and inquiry approaches that are grounded in language and meaningful, authentic exploration should be considered a top priority.

The implications for teachers emerging from this case study are consistent with the following recommendations put forth by Fisher and others (2008) in the practices that support ELL students' learning.

- Plan for "purposeful talk" (p. 45). Intentionally design lessons with a sequence of strategies that work together to build language and share the objectives with students.
- Set up lessons from a "language experience" perspective. Learners "add to the language they already know" (p. 118); and as such, it is essential to listen for them to reveal where they are

currently in their ability to use the language to describe their understanding.

- Use instructional routines that support purposeful talk, such as modeling oral and written language, questioning during guided practice, arranging groups of students for goal-driven collaborative tasks, and asking students to report to the big group after independent tasks.
- Design inquiry lessons in which students predict, test, observe and share the ideas they developed from interacting with materials and phenomena under investigation.
- Construct opportunities for students to talk about these experiences in small groups. Learners' thinking develops while they practice how to use academic language.
- Choose developmentally appropriate assessments of content that not only guide instruction, but also serve the function of building language proficiency.

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