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AUTHOR Bernhardt, Elizabeth; And Others
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INSTITUTION National Center for Science Teaching and Learning, Columbus, OH.
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ABSTRACT

Anecdotal evidence from teachers who teach in bilingual or second language settings indicates that there is a potential for loss of subject matter. This loss is particularly troubling within the context of science learning. This article reviews several projects aimed at developing an understanding of the implications of bilingual instruction in student outcomes and for student success. Twenty students were asked to read four different texts in Spanish: one narrative, and three expository texts which covered science concepts. Children were asked to read and recall the texts in the language in which they felt most comfortable. They were then interviewed in groups about reading in science. In addition, the children's English language California Achievement Test (CAT) scores in reading, vocabulary, and mathematics were collated. All reading scores in Spanish, the second language, significantly intercorrelated (ranging from .83 to a low of .78) and significant relationships existed between the CAT vocabulary measures (in English) and two of the reading scores and between the CAT reading scores in English and three of the Spanish reading passages. It is concluded that the children in the study indicate they are potentially proficient users and doers of science, that this using and doing is visible through literacy-related activities and materials, and is potentially masked by performance assessment. Contains 10 references. (LZ)

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by
Elizabeth Bernhardt
Thomas Destino
Michael Kamil
and
Marisol Rodriguez-Munoz

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By
Elizabeth Bernhardt,
National Center for Science Teaching and Learning;
Thomas Destino,
University of California, Santa Cruz;
Michael Kamil,
Ohio State University;
and
Marisol Rodriguez-Munoz,
Gladstone Elementary School and NCSTL

Millions of children across the globe study and learn their school subjects in a language they neither speak nor read natively. While there are political, curricular, and economic reasons for instruction in nonnative languages, the processes behind such instruction are relatively unclear. Some research has indicated that children are indeed able to learn both school subjects and nonnative languages simultaneously without any measurable detriment to either (Harley, Allen, Cummins, & Swain, 1990). At the same time, however, anecdotal evidence from teachers who teach in bilingual or second language settings indicates that teachers feel that they frequently have to compromise both the language they use and the content the children must learn in order to meet instructional objectives. In other words, in the act of simplifying both the linguistic and the content elements, material potentially gets lost.

The potential loss of content in any subject matter is troubling. It is particularly troubling within the context of science learning—concepts lost or misconstrued even at the most rudimentary levels of science learning may well compound themselves into scientific misconceptions. Considering that 12 per cent of the United States school population receives content instruction in a language it does not speak natively, we at the National Center for Science Teaching and Learning (NCSTL) embarked upon several projects aimed at developing an understanding of the implications of such instruction in student outcomes and for student success.

Our previous work

The research that has been conducted (some of it previously reported in *Cognosos*) indicates that reading and writing activities are critical to the learning of science content for language minority children. Rather than perpetrating the myth that children must learn to speak before they can read and write, our research with second language children in science settings indicates that writing affords children the opportunity to demonstrate their knowledge uninhibited by the time constraints of immediate oral performance and by the social constraints of needing to look and sound like "the other kids" (Destino, Bernhardt, & Rodriguez, 1994; Bernhardt, Dickerson, Destino, & McNichols, 1994). Further, reading offers children a communication channel with which they can work on their own and at their own pace rather than being constrained by the on-line flow of rapid oral speech (Bernhardt, 1994). Reading also allows children to draw on their native language literacy skills to enhance their achievement (Bernhardt & Kamil, 1995). Our NCSTL projects also indicate that more socially-based strategies (or "actively doing science") afford second language children the opportunity to act out their science knowledge nonverbally. This, too, allows children to "reveal" their science knowledge unimpeded by their lack of oral language proficiency; a negative outcome is, however, that it also allows them to "perform" by simply "going through the motions."

Ironically, this second language backdrop is in conflict with what we perceive as the current belief system among science educators: a de-emphasis on reading and writing in order to emphasize performance-based activities; i.e., favoring "doing science" rather than "reading about" science. As documentation, we point to the early iteration of *Science for All Americans* (American Association for the Advancement of Science [AAAS], 1989) that had some focus on reading and writing and by 1993 had disappeared in the AAAS' *Benchmarks for Scientific Literacy*. It was against the backdrop of research in second language contexts and current wisdom in science education, that we began to examine what relationship first language ability has to measures of science content knowledge when taken in a second language and what the relationship between student performance in hands-on, experiential instruction (in a second language) and reading ability in both first and second languages appears to be.

As mentioned in previous issues of *Cognosos*, we have been conducting a large-scale, nine-month longitudinal study as one part of the research agenda at the NCSTL. We have worked, specifically, with 47 native English-speaking children who attend an inner city Spanish language immersion magnet elementary school. The school's program is bilingual in that the children move from a homogeneous language background (English) into another homogeneous language (Spanish). While on the surface the "magnet" is the special instructional program in Spanish for English speakers and Spanish heritage-language children, for many of the parents the "magnet" is the location of the school as a neighborhood school. Fifty percent of the children are African-American; more than 50 percent of the children participate in the reduced lunch program.

In our longitudinal study, 40 lessons in the fourth and fifth grade science classrooms were observed and videotaped from September to May 1994. These observations and videotapes are accompanied by field notes as well as interviews with the children and their teacher. All videotaped lessons were transcribed and then analyzed for recurrent discourse and procedural patterns according to the Green and Mallat (1981) methodology. From the analysis procedure, three "typical" lessons and one "outlier" (i.e., a lesson that did not fit typical patterns) were selected in order to help us better understand the relationship between what we had observed in instruction and how that related to the assessment of the children's science understanding.

What we did

Based upon the content of the four lessons that we chose, we developed independent assessments. "Independent" assessment (defined as an assessment not under the control of the teacher—i.e., the investigators chose the texts for assessment) consisted of asking the children to read four different texts in Spanish (their second language): one narrative and three expository texts. The three expository texts concerned "the scientific method," the classification

of animals, and the planets, Venus and Mercury; the narrative text was entitled "Los campesinos." These texts were linked topically to themes and to previous performance assessments conducted by their teacher.

For this portion of the project, 20 children were selected from the larger group by their teacher and a researcher on the project as representative of children in the classes. These children differed in Spanish language proficiency, motivation, and science knowledge in order to represent the spectrum existing in the classrooms under scrutiny. The children were asked to read and recall the texts in the language in which they felt MOST comfortable. Several days after reading and recalling these texts, the children were interviewed in groups about reading in science. This interview was not conducted within the presence of their teacher. In addition, the children's English-language California Achievement Test scores in reading, vocabulary, and mathematics were collated.

During the last month of the longitudinal study, an elaborate performance assessment in Spanish, an adaptation of Shavelson, Baxter, & Pine's (1991) suggestions, was administered to the same 20 children. The performance assessment integrated the concept of scientific method with the students' knowledge of the concept of "variable" and was about how one would determine the absorbency of a paper towel. The performance assessment was scored according to the Shavelson, Baxter, & Pine scoring rubric and was also videotaped.

What we found

What we found is that all reading scores in Spanish, the second language, significantly intercorrelated, ranging from .83 to a low of .78. Second, we discovered that there are significant relationships between the CAT vocabulary measures (in English) and two of the reading passages (Planetas and Método) and between the CAT reading scores in English and three of the Spanish reading passages (the exception is the narrative, Los campesinos). Third, we saw that the four Spanish reading passages correlate significantly with the two CAT mathematics scores. Fourth, we found that the reading and vocabulary scores on the CAT do not correlate with the mathematics comprehension section, but do correlate with the calculation section. Finally, we found that none of the measures—either the Spanish reading passages OR the standardized achievement test measures taken in English—correlate significantly with the performance assessment measure that we took.

Many of the significant relationships that we found are indeed predictable: tests should correlate with tests and this is certainly the case here. Reading recall correlated with other reading measures, and reading tests correlated with other kinds of tests. But we do not want this interpretation to be trivialized. Correlational analyses are conducted in order to establish the relationship between two variables and to measure the extent to which the same dimensions of abilities are being tapped. Clearly the literacy measures used in the current study (reading recall and standardized tests) tap overlapping abilities, generally referred to in the second language literature as "interdependence."

It is the lack of relationship between reading and performance assessment that is of concern. The children's reading of science did not relate significantly to their performance assessment in science. In other words, their ability to "demonstrate" knowledge did not relate to or overlap with their ability to "glean" knowledge from science texts.

Field notes from the study reveal that the teacher always tells her students that being informed is central to the scientific endeavor. She actively models her "scientific nature" by telling the children about her "at home" science reading. Interview data indicate that this teacher is, in fact, openly critical of works such as *Benchmarks for Scientific Literacy* (American Association for the Advancement of Science, 1993) because they ignore reading.

The children generally commented that reading in science was boring and that narrative was fun. They stated that "science stuff" was boring because "nothing happened"—there was no action—it was just one "fact" after another. The narrative, however, was fun because "you kinda knew what was going to happen next." Interestingly, several of the kids who made this comment were particularly creative in their recall of the text, elaborating, sometimes wildly, on the author's words.

The grade five students were more "literacy aware" than the grade four students. They easily recognized the differences in writing styles, though agreeing with the fourth graders, they thought the narrative text was easier. Also, most of the grade five students rank ordered the texts in terms of difficulty as they read them and could easily compare them when asked to in the interview. A few of the grade five children, those with the most accurate recalls, commented that the science texts were actually easier than the narrative if they knew at least "a little bit" about the topic. These students were less likely to elaborate on the contents of the original text. Although the grade four students were less specific with their comments, they agreed that the topic of the text made a big difference regarding how much attention they gave it.

Those who less successfully recalled the text tended to extract a grain of "truth" from the science text and elaborate such that the result was the creation of a new "narrative" about the original science text. Interestingly, the interview revealed that many of the students had a difficult time distinguishing between the narrative and expository styles.

What our data imply

Our first concern focused on the role of first language performance in the assessment of a functional task (learning about science) in a second language setting. Clearly, there is an important relationship between first language and second language performances. The strength of the correlations between the first language

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(L1) and second language (L2) measures points toward the concept of language and literacy interdependence. These data underline a critical point that all educators *must* understand—that children's L1 performance can be extremely helpful in understanding and predicting their L2 performances and that this information must be put into the mix when children are assessed and decisions made about them.

In addition, we focused on the role of reading in science classrooms for second language students. In parallel to our previous studies about the role of writing in assessment (Webb, et al., 1994), data from this study point to the importance of reading texts for second language learners. It is critical that children's abilities to glean scientific information be tapped, reinforced, and enhanced. Children learning in second language settings can indeed *read* scientific information—they do not need a docent beside them arranging hands–on activities in order to formulate understandings. They *are* capable of understanding science texts in a language they do not completely control. Assessing students' reading of science serves as a window through which educators may view the manner in which children manage other science related activities on a daily basis.

We believe that our study also points toward a number of further research and policy directions about language minority children regarding the relative amount of curricular time devoted to narrative versus expository text. The children reacted strongly to the narrative/expository difference and the quantitative data indicate that a narrative text adds noise to the analysis and deflates its explanatory power.

Second, it is clear from our data that performance assessments do not tell the whole tale of the scientific endeavor. On the positive side, performance assessments clearly tap knowledge other than that which is tapped in reading recall and standardized achievement test measures. *What* that other knowledge is, is certainly not discernible from our data, but needs to be investigated. On the surface, performance assessments are perhaps "more fun and interactive" than what appear to be more "passive" measures such as reading. But do they really challenge the intellectual capabilities of students and help teachers to know where to take second language children in instruction?

We believe that our work provokes the argument that the role of literacy materials is potentially undervalued in second language science instruction and that this undervaluing leads to negative rather than neutral results. All children should be challenged in science classrooms, not let off the hook because they "don't speak the language of the classroom." The children in our study indicate that they are potentially proficient users and doers of science. This using and doing is visible through literacy–related activities and materials and is potentially masked by performance assessment. Many avenues for assessing science learning and many means of gaining and expressing knowledge must be opened and available to children who do not speak the language of the classroom natively.

In our second language studies at the NCSTL we are trying to extract principles for teaching and assessment that will appropriately serve all children who find themselves, either voluntarily or involuntarily, as linguistic minorities in our classrooms. Regardless of status, children who must learn content through a language other than their native language are in double jeopardy when confronted with assessment of any type. That is, they are forced into demonstrating knowledge in a language over which they have only partial, if any, control. This situation is as challenging as it is increasingly significant, as more and more nonnative speakers are added to our school population. To ignore the special challenges created by the addition of linguistic complexity to the learning of science content, is to imperil the success of a large proportion of America's future adult population. We hope our data serve to illustrate how the challenge presented to these students cries out for intelligent and informed approaches to the understanding and addressing of issues related to the assessment of limited language proficient students in science classrooms. ■

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