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ABSTRACT

A study of fourth- and fifth-grade students who were taught science in Spanish as a second language is reported. The primary issues studied were: (1) the role of first-language skills in learning science in a second language, and (2) whether hands-on instruction, seen as effective by many for science teaching, is appropriate for second-language-medium instruction. Forty science lessons were observed and videotaped from September to May. Twenty students read four science texts in Spanish, three expository and one narrative, all linked to themes and previous performance assessments by the teacher involved. Students were asked to read and recall the texts in the language in which they felt most comfortable, then several days later, were interviewed about reading in science. During the study's last month, the same students were administered a performance assessment. Quantitative data and interview results are analyzed together, and implications are drawn concerning the role of first-language skills in second-language performance, the role of reading in science instruction, and appropriate use of performance assessment. (MSE)

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Introduction and Background

The work that we will be reporting on is seated within the data collected as part of a longitudinal study in a fourth and fifth grade science classroom in which the language of instruction is the second language of the students, Spanish. This study is part of the research agenda of the National Center for Science Teaching and Learning that has as its theme external factors that play a role in the learning of science: second languages issues are a set of those factors.

There is a science education backdrop to what we are doing and a second language backdrop to our study that we will speak to by way of introduction. The science backdrop has two relevant dimensions. The first dimension is that there is next to no information in the science education literature regarding second language issues. That is, in a recent survey of science education methods texts, and of teacher-oriented and research-oriented journals published since 1980, we found about 15 pages of material hidden among around 5000 pages of text. To summarize in an understated way: the material is really hard to find and we can essentially argue that no formal knowledge of biliteracy is being or has been infused into the science education curriculum.

The second dimension to the science backdrop is the science education perspective on "literacy" activities and by this we mean on reading and writing. To tell tales out of school,

when introduced as a "literacy person" at a science meeting this past summer, I was asked to "go talk over there." At a less anecdotal level, if one peruses Science for all Americans which is the most visible science education version of "reform" in science education one will see little if any reference to reading materials and, further, almost a denigration of the concept of learning about science through reading--such is the hands-on movement. [As an aside, a bright spot in this regard is the recent publication of a special issue of the Journal of Research in Science Teaching written by researchers from the National Reading Research Center.] I do not mention these dimensions either to criticize science education for ignoring biliteracy (to that extent it is no different from many other fields) or to incite reactions about the role of reading versus hands-on in science education. I merely want to give you some perspective about where science education seems to be oriented.

The second language backdrop also has two dimensions. The first dimension we call the "content miracle" dimension. If you review the second language literature (either research or practice-oriented materials) you will find a pervasive view that is summarized as "teach the content and the language will follow along." This view has developed essentially from the immersion literature, but is clearly well-ensconced in the "LSP" (language for special purposes) literature. [LSP is a language learning model principally for adults focused on some "content" that they already know or need to know such as "Spanish for the medical profession" or "Japanese for engineers"]. The view is also the view found in the popular media to convince parents and school board members that young children can learn language easily and well through content and should be mainstreamed into content classrooms (the "don't worry about this it will all work out in the end" approach).

What troubles us, however, is another dimension: we ourselves as second language speakers do not perceive the content learning/language learning issue to be all that simple; further, and most importantly, we have countless teachers reporting privately (including the one from this study) that they must continually compromise the content to get to the language and compromise the language to get to the content. Again, we do not mention these dimensions in order to incite a debate about the issues for they are surely more complicated that our brief comments allow, but simply to give you a flavor of our larger study.

Research Questions

It was against both of these backdrops that we posed a number of questions about the content-learning situation in general in second language content classrooms and about our own data, specifically. Today, we will only refer to those questions specifically focused on biliteracy. Questions that were troubling us were these: 1) We know from the second language reading literature that first language abilities contribute powerfullv to second language comprehension scores (papers from this session; Bernhardt and Kamil, 1995, forthcoming; among others); given this, what power does that first language ability have in our measures of science content knowledge? 2) Science educators are not particularly supportive of literacy (the reading and writing kind), preferring hands-on experiential approaches--is an exclusive use of hands-on truly beneficial to second language children? We were particularly interested in this when other portions of our data base at the NCSTL had indicated that writing in particular was crucial toward insuring that the science knowledge of second language children was not being underassessed (Destino, Bernhardt, & Rodriguez, 1994; Dickerson, Bernhardt, Destino, & McNichols, 1994). 3) We had

observed second language children using hands-on activities as pantomime--in other words, acting out their science knowledge nonverbally. What we concluded from this was both positive and negative. On the positive side, pantomime allowed second language children to "reveal" their science knowledge unimpeded by their lack of oral language proficiency. On the negative side, we saw children who could "perform" in a "performance assessment" but who admitted they were simply "going through the motions." In other words, was performance assessment in a second language really telling the science teacher what she needed to know about the science knowledge of her students? Another way of stating the question is how does performance assessment relate to other measures of school science knowledge?

Procedures

Armed with these kinds of questions as part of our larger study we embarked upon doing some outside assessments based upon contents on which the children in our 4th and 5th grade classrooms had already been exposed to AND tested on. In the larger study, we spent nine months observing the science lessons in a 4th and 5th grade science classroom in which the language of instruction was Spanish. The children in our study attend an inner city magnet school. We do not wish to mislead by using the term "magnet:" for many of the children in the school the "magnet" is the location of the school as a neighborhood school, not its special program. 50% of the children are African-American; more than 50% of the children participate in the reduced lunch program. The children in our study are what could be called "voluntary minorities." Their parents have chosen to have their instruction in a second language.

We observed and videotaped 40 science lessons from September to May. We also have our 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. From the analysis procedure, we chose three "typical" lessons and one "outlier" (i.e., a lesson that did not fit typical patterns) for independent assessment.

Our "independent" assessment (defined as an assessment not under the control of the teacher--i.e., we chose the texts for assessment) consisted of asking 20 children in our 4th and 5th grade classes to read four different texts in Spanish: 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. 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. We also had access to the children's California Achievement Test scores in reading, vocabulary, and mathematics.

During the last month of the study, we administered an elaborate performance assessment, an adaptation of Baxter, Pine, and Shavelson's 1991 suggestions. The subjects were those same students who had read the four science texts. The children differed in language proficiency, motivation and science knowledge in order to represent the spectrum existing in the classrooms. This performance assessment tried to integrate 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 Baxter, Pine, and Shavelson scoring rubric and was also videotaped.

Findings

Table 1 displays the means and standard deviations of the following scores: variables one through four refer to the recall scores on the texts the children read in Spanish. The texts were entitled "Las planetas" (a text on Mercury and Venus); "El metodo (a text on the scientific method); "La classificacion" (a text about classifying animals); and "Los campesinos" (the narrative text). "Expository score" is the average recall scores across the three expository texts. "Recall score" refers to the average recall scores across all four texts, including the narrative text. The next line is the score on the performance assessment. The final four lines list the scaled scores from the California Achievement Test (CAT) in vocabulary, reading, mathematics comprehension, and mathematics computation.

Table 2 displays the correlation matrix obtained from these data. As you can see from the correlation matrix, all reading performances in Spanish, the second language, are intercorrelated (as they should be), ranging from .83 to a low of .78. Second, you will notice from the correlation matrix the significant relationships between the California Achievement Test vocabulary measures and two of the reading passages (Planetas and Metodo) and between the CAT reading scores and three of the reading passages (the exception is Campesinos). Third, the four reading passages correlate significantly with the two CAT mathematics scores. Fourth, 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 call your attention to the Performance Assessment column--none of our

measures--either our passages OR our standardized achievement test measures--correlate significantly with the performance assessment.

Discussion

Quantitative dimensions. One interpretation of our data is that many of the significant relationships are predictable in that 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 to trivialize the interpretation. 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 our measures tap overlapping abilities. [Actually, in the second language literature this is always referred to as "interdependence"].

It is the lack of relationship between reading and performance assessment that causes us 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. The teacher in our study, Marisol Rodriguez, always tells her children that central to the scientific endeavor is being informed. She actively models her "scientific nature" by telling the children about her "at home" science reading. Our teacher is, in fact, openly critical of works such as Science for all Americans because of its ignoring of reading. We believe that the press toward an exclusive use of performance assessment is ill-founded. What does performance assessment actually tell us about these children and their knowledge of science?

The children's perspective. 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 two literary styles.

Interpretation

We'll try to place our interpretation within the framework of the concerns we mentioned earlier that specifically relate to biliteracy. First of all, what is the role of first language performance in the assessment of a functional task (learning about science) in a second language setting? The other papers in this session indicate that there is indeed an important relationship between first language and second language performances. So, too, does ours. The strength of the correlations between the first language and second language measures points us again toward the concept of literacy interdependence. In fact, as a follow-up, we calculated R square to determine how much variance in the second language scores was attributable to the first language measures. The CAT reading measure accounts for 49% of the variance in the expository passage scores and for 41% of the variance when the narrative text is included. The CAT vocabulary measure accounts for 34% of the variance in the expository texts, and for 27% when the narrative text is included. 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 we must put this information into the mix when we evaluate and make decisions about second language children.

Second, is there a role for reading in science classrooms for second language students? [Remember this question is asked against the science education backdrop that belies the attitude that reading is simply irrelevant and that "real" scientists "do" science, they don't read about. I promise not to begin my discourse against this nonsense at the moment.] We believe that, similar to the data we have from our other studies regarding the role of writing in assessment (Dickerson, et al., 1994), that our data point to the importance

of reading texts for second language learners. [Of course, we believe this is true for all learners, but it is even more profound for second language children who are often denied access to literacy because of impoverished oral language skills--but that's another paper.] We believe that it is critical that we tap, reinforce, and enhance children's abilities to glean scientific information. We know that they can indeed glean information--that they do not need a docent beside them arranging hands-on activities for them to conduct in order to formulate understandings. They are capable of understanding science texts in a language they do not completely understand. We believe that attending to students' reading of science serves as a window through which we may view the manner in which they manage other science related activities on a daily basis.

Our data also hint at the narrative/expository crisis that we are now confronting in schools. The children reacted strongly to the narrative / expository difference and our quantitative data indicate that a narrative text adds noise to the system and deflates explanatory power. Does the heavy and consistent reliance on narrative text potentially lead children (especially those who are not the highest achievers) to elaborate unwisely and to, thereby, reinforce scientific misconceptions? Again, we make no claims, but believe that our study points us in a number of further research and policy directions about language minority children.

Third, we raise caution about the (over)use of performance assessments. We are certain that performance assessments do not tell the whole tale of the scientific endeavor. On the positive side, they 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 us to know where to take them in instruction?

Conclusion

We do not claim through the medium of our investigation to have solidly answered these questions. We believe that on balance within the context of all of our work with second language children in science classrooms, that the role of literacy materials is undervalued 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." Our children indicate that they are potentially proficient users and doers of science and that this using and doing is most visible through literacy-related activities and materials.

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TABLE 1. Means and Standard Deviations For Passages in Spanish and Standardized Achievement Test Scores in English. (N = 20)

Variable	Cases	Mean	Std Dev
LAS PLANETAS	19	38.4	19.2
EL METODO	19	26.8	18.5
LA CLASIFICACIO	19	18.9	16.3
EL CAMPESINO	19	27.5	19.4
EXPOSITORY SC	19	28.1	16.7
RECALL SCORE	19	27.9	16.8
PERF. ASSESS	19	11.2	4.6
VOCABULARY	19	714.8	46.4
READING	19	714.9	43.4
MATH. COMP.	19	723.0	41.2
MATH. CALC	19	731.1	39.1

Note: Missing data resulted in dropping a single case.

Table 2. Correlation Matrix for Variables in the Study. (N = 20)

	PLANETA	METODO	CLASIF.	CAMP.	EXPOS.	RECALL	PERF.	VOCAB.	READ.	COMP.	CALC.
LAS PLANETAS	1.00**										
EL METODO	.80**	1.00**									
LA CLASIFICACION	.80**	.78**	1.00**								
EL CAMPESINO	.84**	.780**	.68*	1.00**							
EXPOSITORY SCOR	.94**	.93**	.92**	.83**	1.00**						
RECALL SCORE	.94**	.92**	.88**	.91**	.99**	1.00**					
PERF. ASSESS	.30	.40	.25	.41	.34	.38	1.00**				
VOCABULARY	.61*	.66*	.54	.33	.65*	.58*	.33	1.00**			
READING	.67*	.79**	.64*	.45	.76**	.69**	.32	.94**	1.00**		
MATH. COMP.	.58*	.71**	.59*	.71**	.68*	.71**	.21	.20	.36	1.00**	
MATH. CALC	.80**	.78**	.70**	.71**	.82**	.82**	.51	.73**	.79**	.61*	1.00**

Note: Missing data resulted in dropping a single case.

Two-tailed test, *p< .01; **p<.001