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ABSTRACT

Comparing traditional to experiential instruction, a study investigated whether teaching content area vocabulary using hands-on experiences and teacher/student interaction would result in greater vocabulary knowledge and better comprehension of a related text than conventional dictionary work. Subjects, 45 fourth grade students from a chapter 1 school in the American Southwest, were evaluated as either low, average, or high ability readers and were assigned to one of three treatment groups that taught or exposed them to 12 vocabulary words regarding the water cycle. The experimental group used the scientific method and teacher/student interaction. The traditional group was required to locate vocabulary words either in the glossary of the textbook or in the dictionary, and the control group received no treatment. All subjects were then administered a vocabulary test based on a passage about the water cycle taken from a fourth grade science book. Analyses indicated significant positive effects for both treatment and reading ability. Findings also showed that the experimental group performed significantly better than either the traditional or control groups, whose performances were not significantly different. The high ability readers performed significantly better than either the average or low groups, which were not significantly different. Results also supported the notion that teacher/student interaction can facilitate overall understanding of a related science text and can be an integral part of the learning process. (Tables of data and 4 pages of references are included.) (JD)

The Role of Experience in Learning Science Vocabulary

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The Role of Experience

in Learning Science Vocabulary

A major demand of science learning is the ability to read and learn from text (Hurd, 1981). It has been reported that 90 percent of science teachers rely primarily on student textbooks for both the curriculum and instruction of science classes in elementary and secondary schools (Yager, 1983), and that elementary and general science is learned primarily by reading (Stake & Easley, 1978). An important variable affecting students' ability to effectively read those science texts is their knowledge of the vocabulary and the underlying concepts represented by those words.

Science textbooks, as other content texts, contain their own unique language. This language can be defined by two types of vocabulary (Vacca & Vacca, 1986). One type, special vocabulary, consists of words found in everyday language but used in a specialized way within the field of science. For example, fruit, energy and exchange are words from everyday language which have specialized meanings in science. The second category of science vocabulary is its technical jargon. These are the words that are unique to the subject, such as photosynthesis, mitochondria and ionization.

Science is a content field which heavily depends upon the use and understanding of specialized and technical vocabulary. An examination of twelve commonly used science texts in grades one through six found, on the average, over 1800 technical words in grade 3 to over 3,000 in grade 6 (Yager, 1983).

To investigate how well students understand these words, Yager and Yager (1984) tested third, seventh and eleventh graders' knowledge of eight science terms encountered at all three levels. Though the 7th and 11th graders performed significantly better than the younger students, no differences were found between the 7th and 11th graders. Since the investigators expected students' understanding of scientific vocabulary to increase during the four years between these grades, their results lead them to the conclusion that vocabulary instruction in science was not very effective.

The positive relationship between vocabulary knowledge and reading comprehension has been repeatedly demonstrated (Clark, 1972; Davis, 1968). However, what has not been evident is the nature of this relationship.

To look at the effects of this relationship in science, an important question to ask is: If students are not learning science vocabulary as well as expected, how might that affect their comprehension of science text? Anderson and Freebody (1981) provide three hypotheses which attempt to explain the relationship between vocabulary and reading comprehension. One, the aptitude hypothesis, states that the correlation is due to a person's ability to think quickly, thereby easily acquiring new vocabulary. A second hypothesis, the instrumental hypothesis, suggests that verbal aptitude alone is not sufficient to learn new words. Rather, in texts with many unfamiliar words, the meanings of those individual words must be taught. The knowledge hypothesis, rooted in schema theory, provides an alternative explanation. It suggests that vocabulary is the label for the ideas they represent. Since those ideas are hierarchically organized and interrelated with other concepts in one's cognitive structure, knowing a word indicates that one actually knows many related words and ideas. According to this hypothesis, it is the reader's expanded knolwedge base that explains the relationship between vocabulary and reading comprehension. A fourth explanation, the "access" hypothesis, is offered by Mezynski (1983). This hypothesis emphasizes the "automaticity" of vocabulary knowledge in which the important factor is how easily the newly acquired words are accessible to the reader.

The viability of any of these hypotheses must be ascertained so that effective vocabulary instruction may be implemented. Studies investigating the effects of vocabulary training on reading comprehension have had mixed results. Those strategies which have resulted in improved reading comprehension have required student interaction with the words and the concepts they represent (Mezynski, 1983). For example, Eeds and Cockrum (1985) demonstrated that students who were required to relate new vocabulary from a novel they were reading through a processs in which they made connections with existing knowledge, gave an example, nonexample, and definition, outperformed another group of students who were to learn the same words through a dictionary look-up exercise. Anders, Bos and Filip (1984) found similar results using an interactive teaching method with high school students identified as learning disabled reading social studies text.

The studies cited above required students to interact with the new ideas on a cognitive level only. Another way to promote active participation and thereby increase the likelihood of not only learning new vocabulary but also using that vocabulary knowledge to comprehend text, is through experiential or hands-on strategies. The Piagetian model of cognitive development, which is often used to describe learning in science, insists that children will learn only if they discover rules about their environment on their own, and that this will occur only through their active participation with the environment (Piaget, 1952). Some science educators (Gega, 1986; Simpson & Anderson,

1981) have used this theory to suggest that the only way for learning to occur in the elementary classroom, where most students are developmentally in the pre- or concrete oeprational stage, is to provide actual "hands-on" experiences from which students can develop appropriate concepts. Empirically, this notion has been supported. For example, Barrow, Kristo and Andrew (1984) developed science vocabulary in young children through the use of a language experience activity in which the subjects used the vocabulary in their explanations of what they saw and manipulated.

Though theory and empirical evidence support an interactive model of teaching vocabulary to develop conceptual vocabulary, typical vocabulary instruction consists of looking up words in a dictionary or glossary followed by using those words in sentences (Thelen, 1986).

Based on the concern of science teachers, typical vocabulary lessons, learning theory, and empirical studies investigating vocabulary acquisition and reading comprehension, the following research questions were asked:

Would teaching conceptual vocabulary using hands-on experiences and student-teacher interaction result in increased vocabulary knowledge when compared to the effects of traditional dictionary work? Would such an activity result in better comprehension of a related text?

METHOD

Subjects

The subjects were 45 fourth-graders from a Chapter 1 school in the Southwest. The ethnic backgrounds of the subjects were Anglo, Mexican-American, and Papago Indian. Stanine scores achieved on the Iowa Tests of Basic Skills (Hieronymus, Lindquist, & Hoover, 1979) Reading subtest were used to identify subjects as either low, average or high ability readers. These three groups were represented by 18, 18 and 9 subjects respectively. (Note: The low number of high readers reflects the overall low reading achievement of fourth-graders at the study site.) Each group of readers was randomly assigned into one of three treatment groups described below.

Treatments

The treatments were designed to teach or expose subjects to twelve vocabulary words (see Table 1) representing important concepts about the water cycle. The words were chosen according to their relevance to the superordinate or main concept (Vacca & Vacca, 1986) presented in the text. The superordinate concept identified by the investigators was: Water on the earth and in the atmosphere is recycled through the processes of evaporation, condensation and precipitation.

The students' science resource teacher carried out all three treatments.

(Insert Table 1 about here)

Experiential

The experiential treatment was designed to facilitate the learning of new science concepts by utilizing the scientific method within the context of the knowledge hypothesis as described previously in this paper.

The teacher had the students participate in an experiment designed to demonstrate condensation and evaporation. The steps in the experiment were: 1) fill plastic cup with water and ice, place it outside, observe changes; 2) pour some water onto the pavement and observe changes.

The teacher directed the students to observe any changes. When they noticed the water forming on the outside of their cups, the teacher would ask questions such as "Where could the water on the outside of your cup have come from?" This led to a discussion of the possibilities (hypotheses), and a further experiment to determine if the water on the cup came from the water in the cup. During this interchange, the teacher would say such things as "Do you know what this is called?" and "We need a name for this."

When the water poured on the pavement began to "disappear", she asked questions such as "Where could the water have gone?" and "How could that have happened?"

Again, as the students learned the scientific concept, the teacher provided the vocabulary word to name it.

When the vocabulary could not be demonstrated, as for the words "rain," "dew" and "hail," for example, they were introduced by the teacher as a logical outgrowth of the ensuing discussion. For example, to teach the concept "dew," the teacher referred to the students' experiences of walking to school through wet grass when there had not been any rain. The students had had the experience, but had not developed the concepts that the wetness originated from the water vapor in the air which had condensed on the grass, and the relationship of temperature to this process.

This type of activity would promote integration of the new ideas and vocabulary with existing knowledge, thus providing and/or expanding interrelated knowledge structures.

Traditional

The traditional treatment required students to find the vocabulary words in the glossary of the textbook containing the original passage, or, if not there, in a dictionary.

Students volunteered to read the definitions, which the teacher then wrote on the board. Another would give a sentence using the word. Sometimes all the students read the definition together and sometimes the group repeated the sentence.

Control

The control group discussed an unrelated science topic during the "pre-reading" time.

Materials

Passage

The text from a 609-word passage about the water cycle was printed from a fourth-grade science book (Chant, 1981). The pictures in the book, photographs of such things as storm clouds and a waterfall, were not considered essential to understanding the main concept and were therefore not included in the reproduced passage.

Dependent Measure

A 20-question multiple choice test was constructed by the investigators. There were twelve vocabulary and eight conceptual questions. All were written in a fill-in-the-blank format, with three choices of answers.

A typical vocabulary question was:

Changing water vapor to liquid water is called _____.

a. evaporation

b. boiling

c. condensation

An example of a conceptual question was:

You can expect to find dew when the air ___________.

a. is very dry

b. is very windy

c. is very moist

Procedure

All subjects participated in one of the three pre-reading conditions, read the passage silently, then answered the multiple choice test. They did not have access to the passage while answering the questions. The entire procedure was completed by all groups within 70 minutes.

RESULTS

Three separate 2-way analyses of variance were conducted to determine the effects of treatment and reading ability on total, vocabulary and conceptual scores. (See Table 2 for groups means and standard deviations.)

(Insert Table 2 about here)

For the total score, significant effects were found for both treatment, F (2,36) = 4.94, $p<.05$, and for reading ability, $F(2,36) = 18.54$, $p<.01$. There was no significant interaction.

Bonferroni multiple comparisons yielded the following results on the total test score:

1) the experiential group performed significantly better at $p < .05$ than either the traditional or control groups, which were not significantly different.

2) the high readers performed significantly better at $p < .05$ than either the average or low groups, which were not significantly different.

Post hoc analyses of the vocabulary and conceptual subtests indicated the same results for both: there were no significant differences due to treatments or interactions; high readers scored significantly better than either average or low readers, which were not significantly different.

DISCUSSION

Effective vocabulary instruction results in student "ownership" (Pearson, 1985) of a word. The word, then, is neither an isolated entity nor a label for a memorized definition, but part of one's cognitive structure. The obvious question becomes: How does a teacher structure vocabulary lessons that result in that ownership? Typical vocabulary instruction consists of looking up words in a dictionary or glossary, and is often followed by using each word in a sentence. Though these activities may result in successful learning of definitions, knowing the definitions alone does not result in improved reading comprehension (Mezynski, 1983; Thelen, 1986).

Active participation by students with new vocabulary has been recommended by many as the best way to learn conceptual vocabulary (e.g., Carr & Wixson, 1986; Nelson-Herber, 1986) and suggested by others as the only means of learning (e.g., Piaget, 1952). Active participation must include a learning environment which supports the integration of what students already know with the new ideas represented by the vocabulary. The nature of the vocabulary in science frequently lends itself to active participation: actual involvement with the objects or processes and therefore hands-on experiences.

As demonstrated in this study, hands-on experiences with student-teacher interaction can facilitate overall understanding of a related science text. The student-teacher interaction was an integral part of the treatment by directing students to make hypotheses based on their previous experiences and knowledge, and by creating the need to use conceptual vocabulary. In this type of learning situation, the role of the teacher extends the text-reader interactive model to, as Peters (1982) suggests, a "text-reader-teacher interactive model" (p.148).

Since subjects in the experiential group were actively involved in both the development of the concepts through the experiments and the use of vocabulary as labels for those concepts, higher scores were expected from this group for all three test scores (total, vocabulary and conceptual).

One possible explanation for the obtained results could be the large number of vocabulary words targeted in the short time period allotted to this study. Twelve words in one lesson was probably too great a number. A second reason for these results could be found in the relationship of the vocabulary to the main concept of the lesson. Though all words were related to the superordinate concept of the text, some of these words were farther than others in a hierarchy of vocabulary (Vacca & Vacca, 1986). For example, evaporation, condensation and precipitation are more closely related to the concept of the water cycle than are hail, sleet and fog.

The teacher who carried out the treatments continued this unit w th the subjects in this study and with the remaining fourth graders at the study site. Her remarks indicated that the students who had participated in the experiential treatment had a head start over the rest of the students in their understanding of the concepts and in their ability to use the vocabulary. Her observations suggest the importance of long term investigations in this area.

The discrepancy between expected and obtained results could also reflect the nature of the text. The text either did not develop the concepts presented thoroughly, or failed to relate them to the overall theme of the water cycle. Instead, it presented isolated incidents of related ideas such as how clouds are formed and how water can change into a gas.

The use of hands-on experiences with other topics in science, with other content fields with suitable vocabulary, and with subjects at other grade levels needs to be examined. Also, to determine how much of the treatment effect was due specifically to the activity and how much to the student-teacher discussion, a further study which isolates these two variables seems warranted.

Researchers need to continue to provide empirical evidence of effective vocabulary instruction that promotes the integration of new conceptual vocabulary with exisiting knowledge structures. Teachers can then apply these strategies in their classrooms to promote meaningful learning of scientific vocabulary, and to thereby facilitate reading comprehension of science text.

TABLE 1

Targeted Vocabulary Words

atmosphere	evaporation
water vapor	condensation
clouds	fog
hail	sleet
dew	humidity
frost	precipitation

TABLE 2

Means and Standard Deviations

TOTAL SCORE (20 possible points)

	Experiential (n=15)		Traditional (n=15)		Control (n=15)			
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Low	9.17	2.48	7.67	1.86	8.17	0.75	8.33	(n=18)
Average	11.17	1.94	7.83	2.04	7.67	1.51	8.89	(n=18)
High	14.33	2.31	13.33	3.06	12.67	3.21	13.44	(n= 9)
	11.00		8.87		8.87		9.58	

VOCABULARY (12 possible points)

	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Low	5.50	1.22	5.33	0.82	4.83	0.75	5.22
Average	6.33	1.97	4.83	1.47	4.50	1.97	5.22
High	9.00	1.73	7.33	1.53	7.33	2.89	7.89
	6.53		5.53		5.20		5.76

COMPREHENSION (8 possible points)

	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Low	3.67	1.63	2.33	1.37	3.33	1.51	3.11
Average	4.83	0.98	3.00	0.89	3.17	1.17	3.67
High	5.33	2.08	6.00	1.73	5.33	0.58	5.56
	4.47		3.33		3.67		3.82

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