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Vocabulary Development in the Science Classroom: Using Hypermedia Authoring to Support English Learners

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Abstract

This study investigated the impact of authoring hypermedia projects on the academic vocabulary development of middle school, ESL students. Vocabulary definitions, in-process verbalizations, observations and semi-structured interviews were the primary means of collecting data and assessing vocabulary growth. The results of this study indicate that hypermedia authoring had a positive impact on students' understanding of grade level, science concepts as well as on student engagement in and attitudes toward vocabulary building activities. Thus, the procedures implemented in this study provide a potential model for teachers to follow as they attempt to facilitate their students' vocabulary and concept development.

According to recent demographic data, over 1.5 million English learners attend public and private schools in California. This number is expected to exceed 2 million by 2015, thus greatly increasing the number of students in need of language and literacy development in English (CBEDS, 2006). This situation mirrors that of many other states where changing immigration patterns have brought native speakers of other languages to schools in growing numbers. In fact, half of all teachers nationally may expect to have an English learner in their classroom at some point in their career. Consequently, the provision of English language and subject matter instruction to English learners is one of the most critical challenges confronting teachers and teacher educators today.

Further exacerbating the situation is the fact that the functions and nature of literacy in today's society have changed. Literacy is no longer defined simply as the ability to read and write. In addition to being able to communicate in oral and written form, to be considered truly literate one must be able to think critically, reason logically, and use technology. As the number and diversity of English learners increase, educators everywhere will need to seek solutions, meet challenges, and embrace changes necessary to ensure quality education for all students. Vocabulary development – particularly academic vocabulary development – is an essential element in any attempt to address these challenges.

Unfortunately, classroom research investigating vocabulary instruction reveals the relative paucity of instructional time devoted to academic vocabulary development. A study of twenty-three ethnically diverse upper elementary classrooms found that only 6% of instructional time focused on general vocabulary, and even less (1.4%) on content area vocabulary (Scott,

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Jamieson-Noel, & Asselin, 2003). Even more troubling perhaps is Feldman and Kinsella's conclusion that "The scarcity of systematic, intentional vocabulary and language teaching has also been documented in programs serving English learners" (2005, p. 1). When one considers that these academic terms and their specialized meanings often pose the greatest challenges for English learners (Folse, 2004), it becomes clear that "intensive instruction of academic vocabulary and related grammatical knowledge must be carefully orchestrated across the subject areas for language minority students to attain rigorous content standards" (Feldman & Kinsella, 2005, p.1).

In a review of studies that focused on technology's impact on language and vocabulary acquisition, Zhao (2005) researched the use of digital multimedia and language as a means of providing this type of instruction. Zhao concluded that technology can be used to facilitate vocabulary acquisition by:

- Enhancing access efficiency through digital multimedia;
- Enhancing authenticity using video and the Internet;
- Enhancing comprehensibility through learner control and multimedia annotations;
- Providing meaningful and authentic communication opportunities through email, chat rooms, and other digital means. (p. 16)

A number of studies have examined the impact of students creating hyperlinked environments, like wikis, on students' language development (Augar, Raitman & Zhou, 2004; Chang & Schallert, 2005; De Pedro et al., 2006; Naish, 2006; Parker & Chao, 2007). These studies suggest that these use of technology can increase student motivation, and also have some positive impact on their writing performance.

Vocabulary Instruction

Researchers in literacy education have articulated the need for all students to become more familiar with learning in hypermedia and web-based environments (Au & Raphael, 2000; Kinzer & Leu, 1997; Leu & Kinzer, 2000; Leu et al., 2004). A hypermedia environment is an environment that supports linking graphics, sound and video elements in addition to text elements. Hypermedia authoring tools, which afford teachers the ability to place the learner in an interactive, contextualized learning environment (O'Hara & Pritchard, 2005), allow students to design their own hypermedia authoring environments incorporating text, images, sound, video and animation by creating links among them. Students can encounter realistic problem situations and choose pathways and strategies to problem resolution. Such learner-centered instructional programming changes the role of the student from passive recipient of information to active learner choosing instructional resources and methods (Spoehr, 1994). In general, these environments promote the use of cognitive and metacognitive learning strategies as students decide how to represent information and what associations to make between the text they are reading and the multimedia component they are utilizing (Carlo et al., 2004). More specifically, these environments can facilitate vocabulary and concept development by utilizing approaches consistent with the following instructional guidelines. There is, however, a lack of research that focuses on the creation of hypermedia environments, and specifically on the impact of having

students create links between multimedia elements and text on their academic vocabulary development.

Relate the New to the Known

Vocabulary instruction is most effective when teachers relate new words and concepts to information students already possess about those words and concepts (Wood, 2001). In effect, teachers must bridge the gap between students' current understanding of a concept and the level of understanding needed to successfully comprehend what they are reading and learning (Kame'enui, 2004).

Promote Active, In-depth Processing

Effective vocabulary instruction must promote active, in-depth processing of words and concepts (Wood, 2001). While active student engagement is an important component of all learning endeavors, it is essential to vocabulary development. Word learning is enhanced when students are actively involved in the generation of word meanings rather than being passive recipients of information (Bransford, Brown, & Cocking, 1999).

Create a Language- and Word-Rich Environment

Another factor that enhances the effectiveness of vocabulary instruction is the creation of a classroom environment that promotes vocabulary development. A language- and word-rich environment is one in which students have frequent opportunities to read, hear, use and discuss new words and concepts. This type of environment fosters *word consciousness* (Scott & Nagy, 2004), an awareness of words and their meanings, an awareness of the ways in which word meanings develop, and an interest in and motivation to develop new word knowledge, all of which support incidental and intentional word learning. The fact that this finding has been replicated in a variety of settings increases its significance (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006).

Support Independent Word Learning

Finally, vocabulary instruction is most effective when teachers help students develop the ability to learn new words independently (Wood, 2001). Teachers cannot possibly teach every word or explain every concept – nor should they try. Students need to be able to identify and learn new words they hear or read. To accomplish this goal, teachers must train students to be strategic by explicitly teaching and modeling independent word learning strategies.

Use of Technology

A large body of research supports the benefits of technology as a means of providing instruction consistent with these guidelines (O'Hara & Pritchard, 2006; Pritchard & O'Hara, 2005; Leu, 2005; Cummins, 2005; Zhao, 2005; Duran, 2005; Pennington, 1996; Zhao, 2003). Numerous other studies demonstrate that students who learn in existing multimedia and/or hypertext

environments show greater gains in areas of language development than students who learn in more traditional environments (Ayersman, 1996; Boone & Higgins, 1992; Charney, 1994; Martinez-Lage, 1997). Studies investigating the impact of student construction of hypermedia environments on language development reached similar conclusions (Goetze, 2002; Lehrer, Erickson, & Connell, 1994; Nikolova, 2002).

Thus, when developing their vocabulary, students benefit from environments that provide contextualized, authentic learning opportunities and engage them in tasks where they use words to communicate in meaningful ways (Hulstijn & Laufer, 2001; Stahl, 1999). When students are interacting in hypermedia environments, or are engaged in the authoring of their own hypermedia environments, they are developing and reinforcing their vocabulary as they make connections among text, images, video, sound and animation. This process encourages students to construct meaning and to make connections to their prior knowledge (O'Hara & Pritchard, 2006). An examination of the research on instructional strategies that positively impact the vocabulary development of English learners, as well as the research on the impact of hypermedia authoring on student learning, provides a strong rationale for investigating the impact of hypermedia authoring on L2 vocabulary acquisition.

Research Questions

In this study we investigated the impact of authoring hypermedia projects on the academic vocabulary development of seventh grade, ESL students. The specific research questions we addressed were:

- What impact does the authoring of hypermedia projects have on students' academic vocabulary development?
- What are student perceptions of hypermedia authoring projects and vocabulary learning?

Research Setting

The fourteen students participated in this research study were randomly selected from a larger population of middle school students at one school site. They had been identified as level 1 (beginning) or level 2 (early intermediate) ESL students on the basis of district test scores and teacher judgment. As can be seen in Table 1, these students' socioeconomic situation, determined by free and reduced priced meals, was similar to that of other students in the district, but lower than county or state averages.

The participants were children for whom Spanish, Russian, Farsi or Hindi is their first language. Other factors such as number of years in the U.S. and levels of L1 proficiency and literacy were determined to provide a context for the study. This demographic information is provided in Table 2.

Table 1: *School Demographics*

| | Enrollment | English Learners | Fluent-English-Proficient | Free & Reduced Price Meals |
|----------|------------|-------------------|---------------------------|----------------------------|
| School | 994 | 247 (24.8%) | 189 (19.0%) | 602 (60.6%) |
| District | 6,876 | 1,859 (27.0%) | 1,102 (16.0%) | 4,426 (64.4%) |
| County | 29,466 | 6,476 (22.0%) | 3,653 (12.4%) | 10,719 (37.1%) |
| State | 6,244,403 | 1,599,542 (25.6%) | 931,869 (14.9%) | 3,006,877 (48.7%) |

Table 2: *Student Demographics*

| Student | L1 Prof (1-5) | L2 Prof (1-5) | Academic Rating | Years in US | Language at Home | ESL level next year |
|---------|---------------|---------------|-----------------|-------------|------------------|---------------------|
| HA | 3 | 2/3 | 3.5 | 3 | Farsi | 3 |
| KM | 3 | 2 | 2 | Born here | Spanish | 2 |
| JL | 4 | 2/3 | 4 | 3 | Spanish | 2 |
| JB | 4 | 2 | 2.5 | 12 | Spanish | 2 |
| AS | 5 | 2 | 5 | 1 | Russian | 3 |
| IT | 4 | 2/3 | 5 | 4 | Russian | 3 |
| IK | 4 | 2 | 3.5 | 1 | Russian | 2 |
| AB | 5 | 2 | 4 | 5 | Russian | 3 |
| AL | 3 | 1/2 | 3.5 | 5 | Russian | 2 |
| OK | 3 | 1/2 | 3 | 4 | Russian | 2 |
| SS | 4 | 2 | 5 | ½ | Hindi | 4 |
| MA | 3 | 2 | 4 | 2 | Farsi | 2 |
| LP | 3 | 2 | 3 | 2 | Russian | 2 |
| RZ | 2 | 2 | 2 | 3 | Spanish | 2 |

Design and Procedures

The research design included both qualitative and quantitative methodologies and was chosen to allow for an in-depth investigation of students' vocabulary development. Working in randomly selected pairs, students created a hypermedia report based on a science unit of study in their classroom, and incorporated into their report a list of target vocabulary words in English. The topic they were studying was vertebrates and invertebrates and was aligned with California state science standards for middle school. The two researchers choose the list of target vocabulary words in collaboration with the classroom teacher.

The instructional activities occurred in three phases. The introductory activities in phase I were designed to help students understand how they associate words with the concepts they represent through images, text and sound. Activities in phases II and III required them to apply this concept to their learning of a set of unfamiliar words.

Phase I: Using Hypermedia to Understand How We Associate Familiar Words with Their Underlying Concepts

The purposes of the first introductory activity were to help students take a metacognitive stance about learning vocabulary, to have students begin to think about multiple ways of representing the meaning of words, and to introduce students to the process of creating slides using PowerPoint. The whole class was asked to consider the word 'computer' and brainstorm ways to explain this word to someone who speaks another language and does not understand the word in English. As students offered suggestions for explaining the word, the instructor typed text and inserted images and sounds into PowerPoint that was projected on a screen so students could see the process. Students suggested multiple ways of explaining the word, e.g., showing the object, showing a photograph, drawing a picture, using the language of the person to whom they are speaking.

The purposes of the second activity were to continue having students take a metacognitive stance about their learning, and to begin to have students think about levels of difficulty in vocabulary. Familiar words were used in this activity to allow students to discuss the different levels of difficulty in words, and to think about how to represent the meaning of words through the use of text and images. The students were asked to look at four words familiar to them and, using index cards, to write and draw pictures explaining these words. They were then prompted to provide as much information as possible about each word. Finally, the whole class shared and discussed which words were easier to explain and why.

The students were then taught how to create hyperlinks using PowerPoint. The instructor brought a prepared PowerPoint presentation and a laptop for each student group with the same PowerPoint file on each computer. The PowerPoint had two blank slides and a number of pre-created slides with images, text, charts and sound to explain a selection of words. Once again these were all words familiar to the students. This allowed students to focus on the process of hyper linking and continue to think about how to explain words familiar to them. The instructor first led the whole class through the process of writing sentences with three words on a blank slide, and then modeled the process of hyper linking on the overhead as students followed along

on their laptops. Next, the students created hyperlinks for an additional three words, which allowed them to practice the process and receive individual help from the instructor. Finally, they were asked to write their own sentences for three additional words and to hyperlink them to the appropriate pre-created slide.

Phase II: Using Hypermedia to Learn the Concepts Underlying New Vocabulary

The researchers created a directed activity in a hypermedia environment in the form of a web-based scavenger hunt, which the students completed in pairs. They went online, read questions, and clicked on links that led them to pages where they could find information to use as the basis for their answers. The students recorded their answers on the computer screen. The questions ranged in difficulty and were spiraled to help students gain an understanding of the vocabulary words and underlying concepts. The linked pages where the students found the answers contained text, images and sounds, allowing them to use these different media components to develop both an understanding of the unit and the target vocabulary.

The purpose of this scavenger hunt was twofold. First, it provided instruction for the students on the unit and opportunities for them to begin to learn and understand the target vocabulary. Second, it furthered their understanding of a hypermedia environment. After completing the scavenger hunt, the students continued to explore web pages provided on the computer and to use books to gather as much information as they could.

Phase III: Using Hypermedia to Reinforce the Concepts Underlying New Vocabulary

Students continued to work with the words as they went through the process of creating a PowerPoint slide representing their understanding of each target word and incorporating text, images, and sound. Working in pairs, students planned and decided how to create a slide to explain each of their words using images, text, and scanned diagrams/drawings. Before they continued with the process of creating the slides, they were required to share and explain their plan to the instructors for input and feedback. They were also required to write two or three slides about their chosen topic that included all the target vocabulary. They then went through the report highlighting each target word and creating a hyperlink between the word and the slide they had created to explain the word. Because they used PowerPoint to create these hyperlinks, the process allowed them to view the highlighted word in their report and the slide with their representation of the word simultaneously. Finally, each pair presented their hyperlinked report to the whole class. During the presentation they clicked on each hyperlinked word and explained the slides they had created.

Data Collection

Vocabulary Development

Three data sources were used to determine vocabulary development. The primary source of data was the student index cards gathered both before and after the hypermedia authoring project. The students were given a set of blank index cards and asked to explain on one side what each of the

target vocabulary words meant. On the other side, they were told to draw a picture or in some other way visually represent the concept the word represents. They were told that they could use English and/or their L1 and that they should provide as much information about the word as they could. Two secondary sources of data were the students' final hypermedia products, as well as individual, semi-structured interviews (see Appendix A) with each participant that the researchers conducted at the end of the project. In these interviews, which were tape-recorded and lasted approximately fifteen minutes each, students were asked to talk about the meaning of each word.

Student Perceptions

Two data sources were used to ascertain the students' perceptions of the hypermedia authoring project: in-process verbalizations and retrospective semi-structured interviews. During these interviews the students were asked their views about hypermedia authoring and how they believed it contributed to their learning of words. In addition, a research assistant conducted observations and collected field notes daily throughout the study. The researchers reviewed these in concert with the in-process verbalizations and interview transcripts to triangulate data and to provide a rich context for the study.

Data Analysis

Vocabulary Development

Based on an analysis of pilot study data of student responses on index cards, the researchers developed a continuum that represents levels of understanding of the target vocabulary words. The categories represented on the continuum are:

- Student provides a complete explanation of the word.
- Student provides a correct but incomplete explanation of the word.
- Student provides an example or characteristic of the word.
- Student provides incorrect information about the word.
- Student provides no information about the word.

Two professors of reading with extensive experience in the area of vocabulary and concept development were asked to conduct a validity check of the continuum. Specifically, the experts were asked to examine a sample of responses from the pilot study and, without consulting the continuum, to identify categories representing different levels of understanding of the target words. At the end, they compared their categories with our continuum and indicated whether their categories conceptually matched those we had identified. Both experts agreed that the five levels of understanding we had originally identified represented valid ways of categorizing the students' responses.

This continuum was then used to analyze the pre and post index cards for this study. The index cards for each student were placed along the continuum, and the frequency of words in each category was recorded. Students' final hypermedia reports were assessed for whether or not the words were used in a meaningful way. Student interview responses related to the meaning of the

target words were analyzed to ascertain the students' conceptual understanding of the words. The data from the interviews was then compared to information students had provided on the index cards.

Student Perceptions

Retrospective interview responses and in-process verbalizations recorded throughout the project were transcribed and coded for emerging themes using the constant comparison method (Miles & Huberman, 1994). Field notes and observational data were also analyzed and used to supplement the preliminary data findings.

Results

Vocabulary Development

The analysis of the index cards revealed that students' understanding of the words increased over the course of the project. Table 3 shows that while on the pre-test 100% of the words were in either the Incorrect or the No Information categories, after the completion of the hypermedia project 69% of the words were in the Correct but Incomplete or Complete categories.

Table 3. *Pre-Post Comparison: Percentage of Words per Category*

| | Incorrect or No Information | Example or Characteristic | Correct but Incomplete or Complete |
|-----------|--------------------------------|------------------------------|---------------------------------------|
| Pre Test | 100% | 0% | 0% |
| Post Test | 22% | 9% | 69% |

Another level of analysis showed that the improvement varied across words. For example, 100% of the index cards for the words 'vertebrate' and 'invertebrate' were placed in the Complete category. However, only 40% of the index cards for the word 'endangered' were placed in the Complete category (See Table 4).

The analysis of the final hypermedia reports shows that students used the majority of the words in meaningful ways. Examining each of the slides that students created as part of their final report reveals the range of complexity across the words. For example, most students found a very simple way to represent the meaning of the word 'vertebrate' on their slides, using text and images. Most groups included an explanation of the word, and a picture of a vertebrate with an arrow from the backbone to the word 'backbone.' However, for many students the meaning of the word 'endangered' was more difficult to represent using text and images. Comparing the analysis of the index cards to the final products we found that when students had used their own

words and used images to represent the concept that the word represents, their index cards placed further along the continuum on the posttest.

Table 4. *Percentage of Words per Category*

| | No Information | Incorrect | Example/ Characteristic | Correct but incomplete | Complete |
|----------------|----------------|-----------|----------------------------|------------------------|----------|
| Vertebrate | 0% | 0% | 0% | 0% | 100% |
| Invertebrate | 0% | 0% | 0% | 8% | 92% |
| Warm-Blooded | 17% | 8% | 8% | 59% | 8% |
| Cold-blooded | 8% | 8% | 8% | 54% | 16% |
| Endangered | 8% | 40% | 0% | 8% | 40% |
| Characteristic | 17% | 0% | 0% | 17% | 66% |

Finally, the analysis of the interviews uncovered that the students learned more about words than is reflected on their index cards. For example one student wrote, "it describes things" on the index card for the word 'characteristics.' However, when this same student was asked in the interview to talk about the word 'characteristic,' he replied "'characteristics' describe the animal or a person. Like a bird have feathers, wings beaks like...stuff like that. People have eyes, hair, skin."

The students also told researchers that showing their understanding of the words in a conversation was easier than to do so in writing: "It is harder to write it down and it is easier to talk about it and tell you." Therefore, the data in Table 3, which only reflect student responses on index cards, is a conservative indicator of student learning.

Perceptions of Learning

When analyzing the comments collected as part of the observations during the hypermedia authoring project, the researchers found that the students were excited, engaged and on task while working. The interviews conducted at the conclusion of the hypermedia authoring task revealed perceptions held by the students about their own learning during the project. Many of the students commented on the impact of the process of creating the slides on their ability to remember the meaning of the word. In other words, the picture created on the slide became a picture in the student's mind. For example, one student said: "I think about what we wrote, what we put on the slides, and if I put the picture in my head, then I can remember..."

Some of the students commented on the process of creating the hyperlinks from the words in the report, and revealed that they believed this process helped further their understanding of the words. Additionally, some students felt that they are more likely to use their own words to represent the meaning of the target words when they are creating slides than they would during traditional instruction, which results in better student learning.

“On slides you think about using your own words (more than when reading and taking notes from a book). I did that and it worked. People listened more (when I gave my report). Like my drawing was my own way to explain cold-blooded and it wasn't confusing to other kids.”

“In this laptop we had to put pictures, describe things, use arrows, scan pictures, something like that....it is better to remember the words that way. Also making hyperlinks is also better to remember the words that way. ...Cause you look at the words again and you look at slides again and it is interesting and you remember.”

Another finding revealed through the interviews was that the students had a better understanding of the words when they created the slide themselves, compared to when another student in their group did the work. Since the students worked in groups, individual students were not always directly involved in the creation of each slide.

“I remember better words I did with M than it was to remember words O and A did.” (O and A were other members of her group. M was the student's partner.)

Furthermore, the students revealed sophisticated perceptions related to the use of hypermedia environments compared to traditional textbooks. Many students commented that access to and availability of information via hypermedia environment was greater and more useful than that in textbooks and other “traditional” instructional materials. They also commented on that fact that they could choose the direction they wanted to take and that they could access the information they needed more efficiently using the hypermedia environment.

“In books there are so many words to read and it is hard to find what you want. It is easier on the computer to find what you need to know. You can go your own way sometimes.”

“(Learning from the computer is better) because it has pictures and more information about things. Like I went to the thing and I was just asking about cold-blooded and it gave me information about it right there. And I knew everything. And everything, like everything is right there and you can find everything. Yeah it has pictures and describing stuff and hyperlinks to stuff. And when you find what you need you can like put it into your slide. Everything is there.”

Conclusions

The lack of a control group was an obvious limitation of this study. However, the researchers conducted this study because teachers at this school indicated that more traditional, text-driven vocabulary activities had not been successful with students from similar backgrounds. The

teachers maintained that even students who had scored high on teacher-created and/or end-of-chapter vocabulary tests often did not develop a true understanding of the concepts they were studying. The results of this study, while still preliminary, suggest that hypermedia authoring offers a promising alternative to these traditional methods.

Hypermedia environments can be tailored to meet the needs of English learners by incorporating an appropriate amount of text for the language level of the students and adding images and sounds. These environments also provide students with learning choices and allow them to navigate at their own pace. The use of this type of hypermedia environment in our project helped students stay engaged, on task, and lessened their frustration level during the learning process. Engagement in the process of hypermedia authoring promotes vocabulary development as students connect new words to their prior knowledge and choose their own words and images to represent the underlying concepts. Thus, the procedures used in this study represent a viable instructional model for teachers in similar settings because hypermedia authoring as described above has the potential to improve both students' understanding of target vocabulary and their attitudes toward vocabulary instruction.

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