ARTICLE

A New Twist on Vocabulary Instruction for Students with Learning Disabilities in Biology

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Abstract

An essential element of science instruction is content literacy. In order to improve literacy specific to science, vocabulary must be addressed. As Jitendra et al. (2004) pointed out, "because learning vocabulary during independent reading is very inefficient for students with reading difficulties, vocabulary and word learning skills must be taught." We provide a summary of an investigation to improve the technology-based vocabulary of students with learning disabilities in a freshman high school biology class. The procedures for the project are provided, along with lessons learned about vocabulary instruction of students with disabilities.

Key Words: *Vocabulary; technology; flashcards; learning disability.*

The *Nation's Report Card: Science 2005* reported that only 29% of all 8th-grade students performed at the proficient level in science (Grigg et al., 2006). According to National Assessment of Educational Progress (NAEP) data, students have shown a decrease in 12th-grade science performance from 1996 to 2005, with scores steadily declining from 150 to 147, where a score of 147–177 is basic, 178–209 is proficient, and ≥210 is advanced.

Although science achievement is an ongoing national concern, the national and international testing data (NAEP, TIMSS, and PISA) fail to show the disparity between students with learning disabilities (LD) and their typically developing peers. Testing often indicates that secondary students identified with LD are producing outcomes below their nondisabled peers in science (Wagner et al., 2006). The National Longitudinal Transition Study 2 (NLTS2) reported that "more than three-quarters of those with disabilities score below the mean across subtests" (Wagner et al., 2006, p. 26). Researchers speculate that students with LD have trouble keeping up in biology courses because of the subject's rigorous language and specialized vocabulary (Yager, 1983; Wandersee, 1985; Lovitt & Horton, 1994; Groves, 1995; Taraban et al., 2007; Kahveci, 2010). Therefore, for students who struggle with language processing and literacy skills, the language of biology must be addressed (Fisher et al., 2009). In addition, as a result of the Individuals with Disabilities Education Act (2004), more and more students are included in general biology, and many are expected to pass high-stakes end-of-course exams. Research has shown that diagnostic–prescriptive instruction often does not occur in general biology classrooms for high school students with LD (Swanson, 1999).

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We examined how diagnostic–prescriptive instruction in biology vocabulary affected pretest, posttest, and delayed posttest scores of students with learning disabilities using paper versus digital flashcards. We randomly assigned 25 students with LD to one of two groups, which used either Study Stack (http://www.studystack.com/), a vocabulary instructional tool, or paper flashcards. For 6 weeks, the students spent 5 minutes per day using flashcards developed through Study Stack. Students in the digital group (n = 13) independently manipulated targeted Biology 1 vocabulary on a computer. Figure 1 shows some flashcards and how they were programmed: the word to be learned (question), the textbook definition (answer), and a helper word or mnemonic (anchor). Students in the paper group (n = 12) used flashcards that contained the same prompts, a question, the answer, and an anchor to support memory integration. No control was used, because all students needed to learn the key words assigned as part of their requirements for the course.

The 5-minute prescriptive practice using the flashcards occurred during the beginning of class. Students used their assigned card type daily to study and potentially master targeted vocabulary words, following these steps: (1) read the question currently displayed and think about what is on the other side of the card; (2) flip the card to evaluate whether you were correct; (3) if you were correct, place the card in the correct pile; if you were incorrect, examine the "Help" portion of the card and then place it in the incorrect pile; (4) move to the next card, repeating until you have reached 5 minutes or have reviewed each of the assigned cards; and (5) graph the total correct in your science notebook. Using this protocol, data from pretest, posttest, and a 2-week delayed posttest revealed that both conditions, paper and digital, led to significant student learning gains (see Figure 2). Semester grades for both paper and digital users also went from failing in the first and second semesters to passing in the third semester. Below, student voices about this prescriptive approach to learning vocabulary in biology, along with lessons learned, are provided for secondary teachers to consider.

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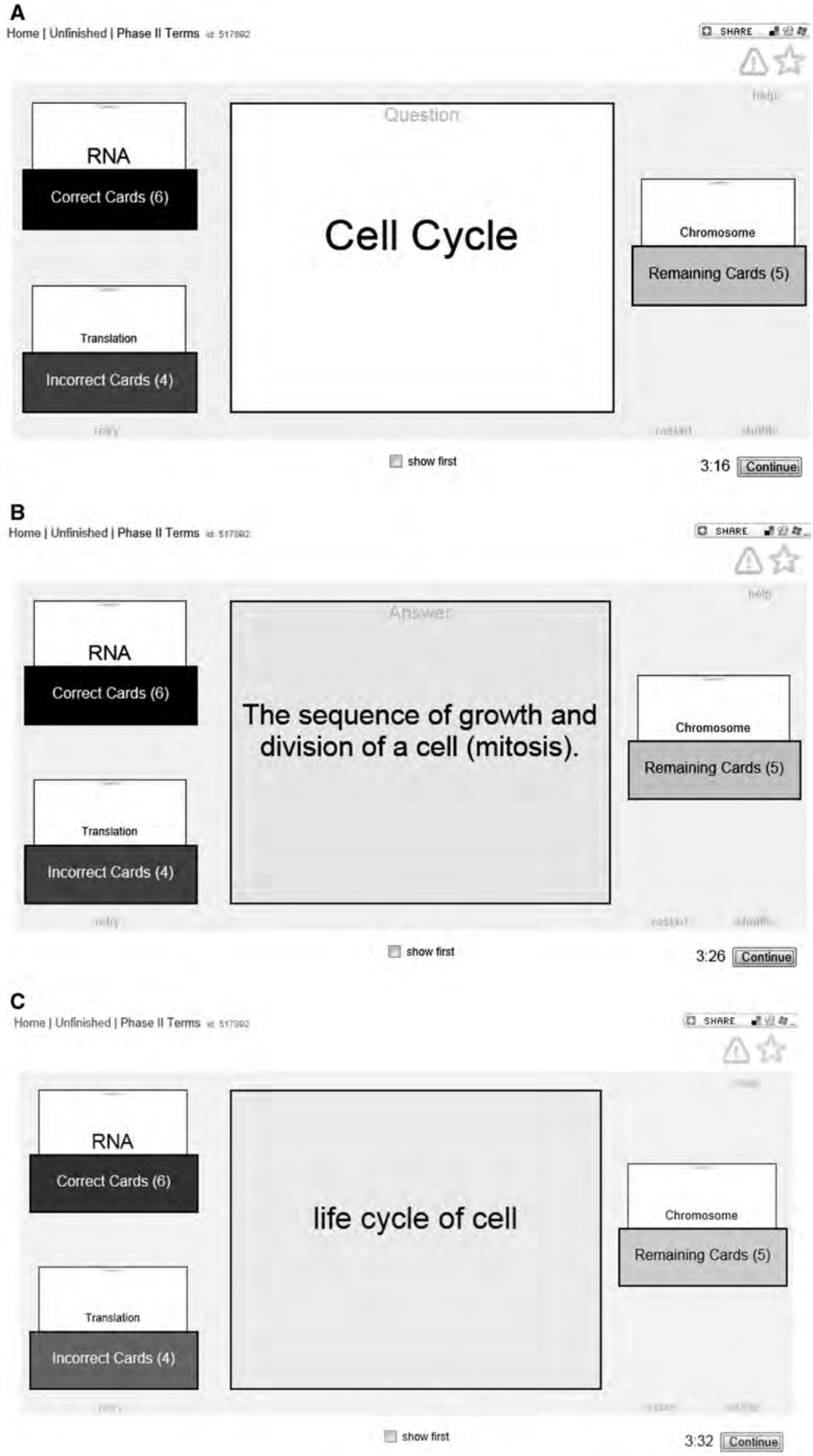

Figure 1. Examples of Study Stack (http://www.studystack.com/) vocabulary cards. (A) The question or word to be learned. (B) The answer or textbook definition. (C) The helper or basic definition.

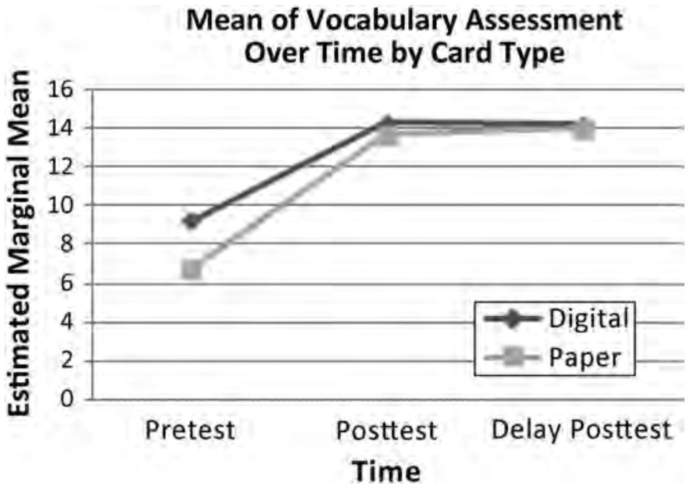

Figure 2. Vocabulary assessment over time, by card type.

○ Learning Vocabulary

Students during the interview validated that the use of the flashcards was helpful and supportive of their learning. One student directly stated that "It was helpful and it really helped me a lot." All of the students interviewed said that the intervention positively supported learning from their point of view. Espin and Deno (1995) found vocabulary knowledge to be the strongest predictor of student performance on content-study tasks. Unfortunately, students with LD often "require more support in the area of vocabulary development [in order] to achieve their academic potential than has been typically offered in mainstream classrooms" (Wannarka, 2010, p. 2). The need for support has been attributed largely to memory deficits of students with language-based LD (Koury, 1996; Carlisle, 1999; Carlisle et al., 2000). The largest body of empirical research aimed at increasing memory and word knowledge for language success in science is mnemonics instruction, especially in the biological sciences. For language development coupled with mnemonics to be effective, the language that is critical for comprehension of the subject matter must first be isolated. Once the language is identified, targeted vocabulary must be assessed. Measuring students' ability to identify words and their meanings are critical to learning content and must drive instruction. Furthermore, identifying the language that is most difficult to learn and then creating learning episodes that allow for frequent, regular exposures of the vocabulary with a memory anchor may affect student learning of new content language.

The Study Stack cards provided students just that – an opportunity to put key vocabulary words into their memory storage with support of a mnemonic device and practice. The need for students to put vocabulary into storage is such that, with content-language recall, students are fully engaging in learning biology content at a deeper level, beyond surface-level factual knowledge. Having scientific language that is automated supports students in making plausible claims and defending those claims within an inquiry classroom.

○ Structured Language Instruction in Science

Empirical biological science research using mnemonics also utilizes highly structured procedures for learning efficiency. The use of structure – including frequency, replication, rehearsal, and monitoring – has value in the learning routines of students with LD, directly translating to increased language growth. Current research supports the use of structure in the learning of Biology 1 vocabulary, and this is further validated by student interviews. One student stated that "If I was stuck, I would just look at the helper words and I would probably get it more." Another student directly mentioned the organization of the routine supporting vocabulary growth: "The way they were organized and displayed really helped, the word and the definition, and then the way for you to remember the definition really helped."

When examining the conceptual category of structure, three subcategories emerged: (1) replication, (2) usability, and (3) time engaged in the task of learning biology vocabulary. All the students interviewed in this research agreed that they would use the flashcards in the future, that using them was easy, and that spending time on the intervention was helpful in learning biology vocabulary.

Time spent on vocabulary instruction is noted as being important within the available research (Stahl & Fairbanks, 1986; Blachowicz et al., 2006). Stahl and Fairbanks (1986) found that data from a meta-analysis supported the theory that instructional time spent on vocabulary teaching is correlated with positive student learning and reading comprehension and learning outcomes. Learning, in this study, was positively affected by spending only 5 minutes daily with vocabulary flashcards.

Students in our study described typical study routines (e.g., vocabulary lists) as being monotonous and lacking in engagement. So how should teachers structure the learning of vocabulary for students with LD? In our study, the special education teacher was given one of two tools that were short yet practical interventions, which she could use in a resource room or even as an alternative teaching model in a co-teaching setting. From this research, it is suggested that teachers identify the most difficult content to access and provide a frequent, short, clear, and ritualistic way for students to practice and recall the language associated with content. A short activity should occur daily and use a fun, engaging way for students to see their learning gains (e.g., graphing). This type of intervention at the high school level needs to be easily managed for both the teacher and the student. For the teacher, this ease of use might be in terms of managing paperwork, timers, and materials. For the students, this process might be in terms of volume of words to master and time spent in intervention. Teachers should keep targeted learning lists short, not to exceed two terms to learn per day, thus 10 words per week as a maximum. They also should allow for brief learning sessions of ~5 minutes is reasonable.

○ Technology to Teach Vocabulary

To date, there is little empirical research using technology tools for increased vocabulary development in the biological science classroom for students with disabilities. Moreover, *The Horizon Report* details emerging technologies in education, reporting that technology is increasingly the means for student empowerment and dramatically affects workforce outcomes (Johnson et al., 2010). The authors of the report stress that students with technology skills will have an educative and workforce advantage. With such dismal outcomes for students with disabilities in both science and the workforce, the field needs to embrace new technologies and ground these skills in high-level content areas.

It was assumed that today's digital-age students would naturally prefer the use of digital flashcards over paper ones. However, that assumption was not true for 100% of the students interviewed: one mentioned that he would have preferred the paper cards. Given that both paper and digital flashcards, paired with a mnemonic device, produced statistically significant positive outcomes, next steps may include students being provided a choice of flashcard type in which to engage. There has been no research on Study Stack to support its use in teaching biology vocabulary to students with LD, but students who were assigned to the digital flashcard group reported that they liked the technology. Specifically: "Well I think it helps because, with all the current technology teenagers these days have short attention spans, so unless they have like you know electronic stimulation they lose focus." Another student mentioned the enjoyment that technology brings: "It was fun." And another said that she would have preferred using the digital flashcards: "I would rather have the computer though."

Any technology used to teach content vocabulary should be replicable, easily accessed, and easily managed, should address the standards, and should be prepared for use well in advance. For example, you can prepare such intervention tools as Brain Pop (http://www.brainpop.com), Flashcard Exchange (http://www.flashcardexchange.com), Flashcard Machine (http://www.flashcardmachine.com), Study Stack (http://www.studystack.com), Quia (http://www.quia.com), or Quizlet (http://www.quizlet.com) with vocabulary that is targeted to the content area.

Overall, increased word knowledge may help students better meet the demands of standardized assessments that have been driving the science curriculum (Eylon & Linn, 1988). All students, including those with LD, must meet the same accountability mandates as their nondisabled peers (Yovanoff et al., 2005). Although some researchers frown on direct instruction in science literacy (Brown & Ryoo, 2008), students with language-based disabilities may not increase proficiency on standardized measures without specific content instruction in vocabulary. Providing instruction to meet the demands of the current assessment reality makes sense for students with disabilities who also have reading and language processing deficits. Therefore, students with LD, whose primary deficit is language-based, must be taught content biology terms to increase the likelihood of passing high-stakes science exams typically required to earn a standard diploma.

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