STUDENT AND TEACHER PERCEPTIONS OF A MOBILE-BASED BIOLOGY VOCABULARY STUDY TOOL FOR ENGLISH LANGUAGE LEARNERS

by

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

STUDENT AND TEACHER PERCEPTIONS OF A MOBILE-BASED VOCABULARY STUDY TOOL FOR ENGLISH LANGUAGE LEARNERS

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English language learners studying biology face a dual challenge of mastering both content and language. Teaching ELLs how to engage in scientific discourse using appropriate language to ask, answer, explain, and make predictions about science requires a foundational knowledge of content-specific vocabulary. This study used qualitative interviews with intermediate-level ELLs at an American high school to learn how a supplemental iPod-based vocabulary review tool influenced their perceptions of learning biology vocabulary outside of classroom hours. Interviews with their biology teacher were also used to complement student testimony from the point of view of an educational professional with ELL teaching experience. Past studies in the area of mobile learning have primarily employed questionnaires to gather feedback from participants. This research study adds greater participant voice to the body of literature that encompasses mobile language learning, second language acquisition, and science education by presenting nuanced opinions from both students and teachers. This dissertation

concludes with a discussion on the influence that this study could have on further research in the fields of mobile learning, academic vocabulary, and student learning behaviors.

1. INTRODUCTION

Federal legislation has had a heavy influence in education policy for minority language students over the past decades. The National Defense Education Act of 1958, created during the era of the Cold War and the launch of the Sputnik satellite, was a political strategy designed to use public education to combat national security threats from abroad by prioritizing technical fields of study. Although this legislation is most often cited as the spark that advanced science, mathematics, and technology education for a generation, it also funded a wealth of foreign language programs, making it the first federal legislation to include a linguistic discipline as a priority in education policy goals (Pulliam & Van Patten, 1995).

Unfortunately, the focus on language did not include foreign language minority students. It was not until the Civil Rights Act of 1964 that schools were required to enroll pupils without discriminating on the basis of race, color, sex, or national origin. This civil rights inclusion was not easily won, nor easily executed. Minority language students, also called English language learners (ELLs), continued to suffer prejudice and lack of adequate resources until the 1980s when the landmark Supreme Court case of Doe v. Plyler in 1982 stated that schools could not discriminate against children based on their citizenship status (Pulliam & Van Patten, 1995).

Over the last 15 years, the population of ELLs in K-12 public schools has grown exponentially. According to Wolf, Herman, Bachman, Bailey and Griffin (2008) there were approximately 5.5 million English language learners encompassing a diverse group of over 400 different languages. The swell in ELL population represents a 53% growth in enrollment from 1997 to 2002 (National Clearinghouse for English Language Acquisition, 2002). This sudden growth means that schools have had relatively little time to develop strategies to assist ELLs in meeting the educational standards expected of all students in the United States (Hancock, 2002) in both specialized English language courses as well as general education classes in the sciences and humanities.

The 1994 reauthorization of the Elementary and Secondary Education Act (ESEA), also known as the Improving America's Schools Act, defined a limited-English proficient student as one who "has sufficient difficulty speaking, reading, writing, or understanding the English language and whose difficulties may deny such individual the opportunity to learn successfully in classrooms where the language of instruction is English or to participate in our society" (Section 7501). The most recent reauthorization of the Elementary and Secondary Education Act (ESEA) of 1965 placed the responsibility of detailed accountability on states and school districts that receive federal funding. Commonly referred to as the No Child Left Behind Act of 2001 (NCLB), this reauthorization required schools to focus on providing high quality education in order to produce better outcomes for all subgroup populations, including students with limited proficiency in English. Title III of NCLB specifies that state education agencies are expected to help these students gain proficiency in English and meet the same academic

content standards as native English-speaking students (Section 3211). But the search for best practices to raise academic achievement of this linguistically diverse group has uncovered differing opinions about second language acquisition pedagogy (Hancock, 2002).

Finding ways for students from various linguistic and cultural backgrounds to develop aptitude in the sciences has met with a great deal of frustration from educators. According to Rutherford (1990), memorizing technical vocabulary is too often the singular focal point of science learning, a task that does not require students to construct their own meanings about the natural world around them. This widespread practice of concentrating on technical terms has been reinforced by standardized assessments that do not prompt students to inquire, experiment, or conclude. In short, science is about producing knowledge, but students learning science are not being asked to do such a thing (Rutherford, 1990). This phenomenon is not localized in ELL classrooms, but the problems associated with it are magnified with this population for whom technical vocabulary requires a specialized level of understanding that contrasts with the colloquial English taught in language arts courses (Carrier, 2005; Miller, 2009).

Statement of the Problem

Research by Carrier (2005), Duran, Dugan and Weffer (1998), Jaipal (2001), and Miller (2009) has demonstrated that English language learners have unique learning challenges when studying the vocabulary-rich subject of biology. They require specialized language support to both comprehend and utilize scientific terms and phrases. It is common for content teachers to believe that ELLs merely need to be taught the same

target vocabulary as native English-speaking students (Jaipal, 2001) or that they can find translations using dictionaries (Miller, 2009) but these simplistic responses have not been shown to satisfy the complex challenge of acquiring both language and scientific literacy simultaneously. Data collected from 2006 to 2009 by the Virginia Department of Education (2009) showed that ELLs consistently scored lower on the Virginia state biology exam than their counterparts in the White, Black, Asian, Hispanic, American Indian, and Low SES subgroups. This persistent gap demonstrates a need for instructional strategies to address specific needs of ELLs engaged in learning both biology content and scientific language. Although the ongoing achievement gap could be related to many components in learning, Carrier (2005), Jaipal (2001), Miller (2009) and Smith (2008) all point out that the highly specialized lexicon of biology vocabulary is likely one of the strongest variables.

Rationale for the Study

This study encompasses a diverse set of disciplines, including educational technology and second language acquisition. The justifications behind conducting the research likewise cover an array of subjects.

Vocabulary Study

Science education for English language learners relies on mastering a great deal of fundamental academic language in a limited amount of time. Biology content is especially challenging due to the specialized grammar (Halliday, 1993) and vocabulary (Jaipal, 2001; Roth & Barton, 2004) used to describe concepts. This problem is compounded by the fact that many ELLs who study biology in high school are still in the

developmental stages of learning English. Building linguistic proficiency within the discourse of science involves not only the use of the four basic communication components stressed in second language acquisition (reading, writing, speaking and listening), but also the ability to use academic knowledge and terminology to communicate about science (Lee & Fradd, 1996). Teaching ELLs how to engage in scientific discourse using appropriate language to ask, answer, explain, and make predictions about science requires a foundational knowledge of content-specific vocabulary to construct the higher-level idea exchanges required by scientific inquiry.

Mobile Technology

It is unlikely that state and federal pressure on schools to raise achievement rates for individual subgroups will decrease. Educators must therefore look for ways to differentiate instruction to meet the needs of diverse learners, especially those with limited English proficiency. Language learners have a long history of adopting technologies that can increase opportunities for written and oral practice to achieve fluency in a way that meets individual learning styles (Kukulska-Hulme, 2009), including multimedia, internet resources, and automated response systems. Given this evidence of extensive technology adoption, the education sector will likely continue to use ubiquitous consumer technology platforms to increase learning opportunities for students (Leu, 2000).

One such platform that has experienced recent growth is mobile technology, which has shifted attention away from PCs as the main source of computing for a growing number of individuals (Pew Research Center, 2010). Cell phones and portable

media players have become popular with students who use them for entertainment devices, but recent initiatives discussed in Chapter 2 of this study have shown that these devices may also be useful resources for education as well. It may be possible that portable devices can impact student learning outside of school. English language learners who struggle with mastering language-heavy content in a formal classroom setting may particularly benefit from this format of learning. To understand how ELLs might take advantage of mobile assisted language learning, or MALL, as described by Chinnery (2006), it was necessary to examine how both students and teachers perceive mobile device-based study tools as an extension of classroom instruction.

Purpose

This study investigated biology students' perceptions of their experience independently using an iPod Touch-based mobile study tool to complement classroom learning. Interviews with the students' biology teacher, an educator with a strong background in language acquisition teaching and learning, were also used to supplement student testimony.

Research Questions

The main question that drove all subsequent questions in this research study was as follows:

What were the student and teacher perceptions of introducing an iPod-based software vocabulary review program into the study habits of an ELL Biology class?

To address this question appropriately, two questions were developed to seek both student and teacher perceptions. These questions were designed to investigate opinions and attitudes that are most appropriately acquired through qualitative means.

RQ 1: How did these ELL Biology students perceive the iPod-based vocabulary tool as a means of informal study?

RQ 2: How did this ELL Biology teacher perceive the effect that the vocabulary tool had on her students' learning behaviors?

Significance of the Study

This study endeavored to fill the gap in the existing literature on technology-aided vocabulary learning for ELLs studying scientific content. Research conducted by Fang (2006), Gibbons (2008), and Miller (2009) discussed the special challenges faced by ELLs learning science, but few of the mobile technology studies completed as of 2011 have been focused on acquisition of content-specific language. The studies that had been done involving ELLs in science-learning situations were classroom-based and dependent on teacher guidance for comprehension (Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Fang, 2006; Halliday, 1993; Roth & Barton, 2004; Santa & Alvermann, 1991). Other research by McGuigan and Weil (2008) and Thornton and Houser (2005) that employed more independent study behaviors had not attempted to do so with ELLs learning specialized science vocabulary. In contrast, this study sought to understand how ELL students engage with a biology-specific vocabulary tool informally, away from classroom activities.

The information provided in this study may offer biology teachers of ELL students a tool for increasing student comprehension of vocabulary knowledge and engagement in independent learning. In turn, this may allow students to better understand the relationship between their independent study habits, vocabulary acquisition, and biology concepts.

Policy Significance

The growth of mobile learning as a division of learning technologies has increased significantly in recent years (Kukulska-Hulme, 2009). The U.S. Department of Education's Office of Education Technology' National Education Technology Plan identified mobile devices as drivers of change in content delivery. Acknowledging the need to engage students in learning methods that match their out-of-school learning experiences, the report recognized that teachers must adapt their methods to "leverage technology to create relevant learning experiences that mirror students' daily lives and the reality of their futures" (U.S. Department of Education, 2010, p. 9). The report also specified English language learners as a group that can be marginalized by typical educational settings and may greatly benefit from flexible, adaptable technology (U.S. Department of Education).

There is evidence to support that this mobile learning initiative is well underway. According to Johnson, Levine, Smith and Stone (2010), universities have integrated smartphone application development into hundreds of different projects in humanities and science courses, including programs to log records of insulin levels, combine current and historical maps, and track outbreaks of disease. The Virginia Department of

Education also started several projects involving mobile devices, including iTunes U podcasts and the Learning Without Boundaries project. This project explored the potential for handheld mobile technologies to be integrated into standards-based curriculum in elementary and middle schools and included the annual Virginia Mobile Learning Apps Development Challenge, an ongoing software competition to produce free educational tools to enhance independent student learning via mobile devices (Virginia Department of Education, 2009).

Because these mobile technology initiatives are still in their early stages, at the point of this study there have been few attempts to develop programs for targeted audiences such as ELLs, special education students, and homebound or distance learners. There may be potential to enrich the educational experiences of these subgroups outside of the mainstream population and give them tools to access learning on unique levels. Furthermore, it is worthwhile to determine if special populations such as ELLs benefit from mobile learning as more people use mobile devices to access information. The Pew Research Center's (2010) survey on mobile device usage showed that a growing percentage of people, especially minorities, are using mobile devices rather than PCs handle tasks such as email and access the internet. As school districts review their technology budgets for upcoming years, there will likely be more interest in the adoption of mobile devices as portable computers for educational use and these funding choices will be influenced by the existing research in real-world settings. Although as of 2011 there were a few research studies involving mobile learning, the body of literature was relatively modest and was comprised of primarily small-sample quantitative evidence.

This study, with its focus on student and teacher perspectives of MALL, expands the literature by adding not only a qualitative perspective, but one that captures the voices of minority learners.

Researcher Perspective

Qualitative research requires that the researcher identify potential biases and personal interests about the topic so that the information within the study may be fairly judged and weighed (Creswell, 2003). This section presents my research perspective, as well as my involvement with the development of the vocabulary study tool that will be used informally by students.

I was an English as a Second Language (ESL) teacher at the school where this study took place, and worked at this site for seven years prior to conducting this research. In those seven years, I taught English language, literature, and basic mathematics to ELLs, but never taught or worked with a course in science or biology.

My awareness of the problems facing ELLs studying biology came from casual conversations with other teachers working with ELLs on science concepts. Intermediate and advanced students take a number of mainstream classes, but biology consistently stood out as the most difficult mainstream class year after year (Virginia Department of Education, 2009). I observed students struggling to learn biology during class and then relaxing with their iPod devices after class. As a language teacher, I began to wonder if there was a way to use iPods as a means to help them learn biology terms. I searched the many biology-themed study applications available in the App Store, but all were either too expensive or focused on science concepts rather than vocabulary only.

I considered this problem for several months before approaching an iPhone application developer to create a program for biology vocabulary review. The developer had already produced a multiple-choice trivia game template that I had used and found to be both quick to play and engaging. The developer agreed to modify the existing trivia game to contain biology vocabulary questions in place of trivia questions, if I could provide a database of appropriate questions. Having no background in biology myself, I asked the ELL Biology teacher if she could create the questions. She agreed, and spent several months creating multiple-choice questions that fit the parameters of the existing game. This database was then sent to the developer who modified the existing game to create a vocabulary study tool. The application was uploaded to the App Store by the developer and was made available for download for free to any iPod user. I did not believe that this vocabulary study tool could be a substitute for the classroom-based instruction students currently received in school. However, based on the literature, I was inclined to believe that it had the potential to enhance that instruction by using technology that was already popular with students.

Definition of Terms

English Language Learner (ELL) – Term used to describe a student whose first language is not English. ELLs can also be referred to as English as a Second Language (ESL) students or as students of English for Speakers of Other Languages (ESOL).

ELL Biology Class – An ELL-only class that was the focus of this research. It was taught by a biology content instructor using the same content, pacing, and common assessments

as other biology classes within the school. All students enrolled in this class were either intermediate or advanced-level ELLs.

World-Class Instructional Design and Assessment (WIDA) – English language exam used by 27 states to identify and classify ELLs into six levels of proficiency. The full name for this exam is the World-Class Instructional Design and Assessment: Assessing Comprehension and Communication in English State-to-State for English Language Learners (WIDA ACCESS for ELLs), but it is known colloquially within this school district as "the WIDA."

Informal Study - Activities involving the pursuit of understanding, knowledge, or skill that happens without the presence of externally imposed curricular criteria (Livingstone, 2001). The emphasis in this learning is self-directed rather than teacher-mandated.

Mobile Learning – Learning that takes place on portable, handheld devices such as cell phones, portable media players, PDAs, or tablets. Mobile learning does not include laptops as portable devices (Traxler, 2009). Mobile learning often happens outside a classroom setting and uses small chunks of time for study rather than extended periods.

Mobile Assisted Language Learning – A division of mobile learning that focuses solely on developing foreign language skills by using portable, ubiquitous device components such as applications, text messages, cameras, and GPS tags.

2. LITERATURE REVIEW

This study, focusing on using iPods to deliver biology content words in informal settings, is not an expansion or replication of a specific research project. Instead, it is a blend of several previous studies on mobile learning, language education, and independent study habits. Although studies on language acquisition, mobile learning, science, and study habits exist, few of these studies overlapped to form a concentrated pool of relevant research that would directly apply to my research questions.

To find pertinent information for my research, I searched ProQuest Research Library, ERIC, Academic Search Complete, PsycINFO, and Wilson Web for the following terms: *MALL, iPod, mobile learning, game, biology, science literacy, ESL, second language acquisition, study habits*, and *independent learning*. Each search only returned a small number of relevant studies, approximately one to three per search, so bibliographies of these studies led me to books and articles that were used to expand the fund of knowledge and create the analysis detailed in this chapter.

Information from these individual areas of research is contained within this literature review, which features three fundamental areas of knowledge that support this study. The first is the effect that independent study opportunities have on student motivation and achievement. Several studies on study habits are introduced, analyzed, and connected to this research on iPods and English language learners. The second

fundamental area of knowledge is an analysis of the academic language challenges faced by English language learners within a science classroom. These challenges may not be exclusive to ELLs, but are routinely documented as problems for this particular subgroup. The final important area for understanding this research is developing an awareness of how mobile technology has been used in second language acquisition research as of 2011. In this section, I will analyze two studies that had significant influence in guiding my research.

Independent Study Habits

A particular focus of my study of the ELL Biology class was the perception that both the students and teacher have of the iPod vocabulary study tool. Although previous studies detailed in this section relied on computers rather than mobile devices to deliver the study materials, they also collected data on student perception. This was done to discover the qualities that made an independent study tool both popular and effective with users. The studies described in this section are relevant because they provided a research base for the multiple-choice format employed by the iPod vocabulary study tool in my study.

There are several studies that have explored the effects of web-based study tools on academic achievement. Grabe and Seigler (2002) explored student study behavior when given an option of online study tools. University students in an Introductory Psychology class (n=191) were given access to four types of tools via an internet-based portal: lecture notes, book notes, multiple-choice quizzes, and short answer questions. Tracking software counted both the number of page views for each tool and how much

time was spent per page. Through this software, it was determined that lecture notes and multiple-choice quizzes were the most popular choices. Book notes were accessed sparingly and short answer questions were accessed so rarely that no data were collected. Researchers found that students who used the online tools performed significantly better on the three class exams than those who did not use the online tools. Online tool users comprised approximately 25% of the class population and performed better overall on class assessments than those who did not access the online tools.

This information was expanded upon by Johnson (2007), who also introduced online quizzes and study groups, along with paper-based quizzes and study groups, as study options with another group of college students (n=48). Data in her research compared groups of students based on learning styles that were determined using questionnaires. She discovered that students preferred face-to-face study groups to online meetings, but liked online quizzes more than paper-based quizzes. Her research found that both active and visual learners showed a greater preference to the online treatments than students identified as sensing and sequential learners, but all students responded well to the online quiz treatment. Online quizzes were shown to positively affect performance and interest when compared against other study tool options. This could be due to a variety of factors but Johnson speculated that the immediate feedback and visually stimulating interface could be two reasons why students showed preference for this study format. Furthermore, Johnson noted that the language demands required of students were nominal for online quizzes when compared to the language demands of verbal study

groups or short answer questions that required written responses, which may also have influenced the participants' preference.

Regardless of language demands, Nonis and Hudson (2010) found that the amount of study time and the type of study tool used did not matter if students were unable to give their full attention to the task at hand. They discovered that if students were not able to concentrate, no study tool variable could effectively improve learning. Nonis and Hudson also found that, of the 163 college students sampled in their research, those who waited until the last minute to study showed greater academic achievement than those who followed a consistent, organized study plan. This "cramming" strategy has been shown to work more effectively with advanced learners than with high school-age students (Nonis & Hudson, 2010), but it provides a foundation of legitimacy to a certain type of learning style that could benefit from a mobile vocabulary study tool.

Summary of Study Habits Research

These three studies demonstrated a number of interesting qualities about using computers for independent study. First, online or technology-based tools are attractive options for learners, even when provided with traditional face-to-face study groups as an alternate option. This may be due to reduced language demands or a greater sense of control when interacting only with a computer study partner rather than a live partner. Second, multiple-choice quizzes have an appeal for independent learners because they offer immediate feedback on a student's progress. Finally, the efficacy of independent study tools relies greatly on individual study behaviors and tools that allow for "cramming" might fill a niche that lengthy review sessions cannot satisfy.

Based on the conclusions from these studies, the iPod vocabulary tool used in my research with ELLs was designed with a multiple-choice format and could be accessed at any time, allowing students the option of squeezing in a quick review period before a class or assessment. However, the tool's format is only one part of its appeal to students. To further understand the importance that the mobile vocabulary tool could have on ELLs' academic performances, it is crucial to recognize the linguistic challenges that ELLs face when enrolled in vocabulary-dense subjects such as science.

Academic Vocabulary and Language

There are multiple scholars who advocate that science teachers move away from vocabulary-focused instruction and into deeper scientific inquiry with ELLs (Carrier, 2005; Duran, Dugan & Weffer, 1998; Jaipal, 2001; Lemke, 1990). Lemke (1990) advocated that to have a deep understanding of science, students had to be able to talk about science, including "observing, describing, comparing, classifying, analyzing…in and through the language of science" (p. 1). Discovering ways for ELLs to reach the goals set by Lemke will likely increase in urgency if ELLs continue to achieve lower proficiency levels on federally mandated, high-stakes standardized tests (Virginia Department of Education, 2009).

The studies detailed in this section illustrate that a clear, persistent challenge within science classrooms may be an exclusive focus on content vocabulary at the expense of deeper scientific knowledge. It is a common practice for teachers and students to concentrate on the target content words provided by textbooks and overlook the ways in which those words are used in writing and discourse (Carrier, 2005;

Rutherford, 1990). Carrier (2005) and Jaipal (2001) both mentioned that teachers should not rely on vocabulary transfer from L1 to L2 to achieve a deep understanding of scientific concepts because scientific language in English carries a special literacy demand that cannot be met by vocabulary knowledge alone.

An example of science literacy demands can be found in Duran, Dugan and Weffer's (1998) research about a high school ELL science class. They studied ELLs in a Grade 10 biology class (n=14) that focused on oral dialogue as the primary means of learning and discovered that students required explicit, repeated modeling of scientific grammar phraseology to learn how to form the phrases on their own, a behavior the researchers referred to as 'ventriloquation'. The results of this ventriloquation were most successfully seen in written assignments because students found it awkward to use scientific grammar orally in place of conversational grammar. Jaipal (2001) expanded this idea of explicit oral modeling when she studied fifty Grade 11 biology lectures over an eight-month period to see how the teacher used science words in class. Using interviews to gather information about student opinions on scientific language, she discovered that students' knowledge of conversational English did not help them when completing science assignments. Merely acquiring a new L2 label for a word they knew in their L1 did not guarantee comprehension. She concluded that L1 to L2 language transfer was not a reliable measurement of understanding and that explicit teaching of scientific grammar and appropriate context could help ELLs acquire the scientific knowledge advocated by Lemke.

The mastery of scientific grammatical patterns for relating ideas and constructing meaning should be the goal of biology teachers (Carrier, 2005; Duran, Dugan & Weffer, 1998; Jaipal, 2001; Rutherford, 1990) but this goal must be approached very carefully. Building patterns about scientific ideas and how to express opinions about them requires that biology teachers be informed about language acquisition pedagogy and how to apply it in classroom settings (Carrier, 2005). Students need multiple experiences with science vocabulary and academic grammatical patterns to "talk science" (Lemke, 1990, p. 1), as well as explicit modeling to learn how to properly apply words and syntax (Duran, Dugan & Weffer, 1998). Simple "show and tell" lectures about vocabulary words are not enough to achieve this complex goal (Jaipal, 2001).

Fang (2006) performed a comprehensive examination of science language found in middle school textbooks and produced a list of eleven expository features used in science textbooks that can be difficult for students, especially English language learners, to understand, including technical vocabulary, conversational words with non-vernacular uses, and subordinate clauses. Lengthy nouns, passive voice, and extended noun phrases are further expository features that can prevent ELLs from fully comprehending science content in textbooks. ELLs who are still developing literacy skills in English are tasked with the additional demands of locating information within texts, interpreting that information, applying it to tasks, and explaining their work, all the while using academic and content vocabulary that they may not completely understand (Best, Rowe, Ozuru & McNamara, 2005; Carrier, 2005). It is clear that a deeper understanding of the unique

nature of scientific grammar and vocabulary is necessary for developing a set of skills to teach science literacy to English language learners.

Scientific Grammar and Literacy Development

Science literacy and its importance to creating students capable of the critical thought needed to engage in scientific discovery has been a topic of research for a number of years. Lemke (1990) pointed out that students learn the language of science "the same way we learn any other: by speaking it with those who have mastered it and by employing it for many purposes" (p. 1). But scientific language has such a small, niche role in students' lives that they have fewer opportunities to absorb and employ it than social language. Even when students are immersed in a scientific setting, such as a biology classroom, they may resist engaging in scientific talk. Halliday (1993) characterized scientific English as "a 'jargon' which has the effect of making the learner feel excluded and alienated from the subject-matter" (p. 69). He also pointed out "it is not only ESL students who find problems with scientific English—so also do many for whom English is the mother tongue" (p. 69). He speculated that the root of these problems, for both English learners and native English speakers, is the same and that teachers might try to solve this problem by watering down scientific jargon in favor of plain English, a method he did not support.

As Halliday mentioned, it may be a challenge for native English-speaking high school students to think like scientists, but the challenge is exponentially greater for those who are still in the developmental stages of learning English as a second language. Carrier's (2005) analysis of science literacy strategies for ELLs noted that when teachers

focused on vocabulary without modeling its use within scientific grammar, it created a literacy gap between ELLs and their native English-speaking peers. This gap is often a result of English language learners being competent in conversational English, but perhaps lacking sufficient background in academic inquiry, textbook interaction, and critical thought that are necessary to be literate in the discipline of science. Furthermore, they may not have had the five to seven years of exposure to academic English vocabulary and sentence structure that seems to be required to achieve the "academic fluency" necessary for learning in secondary and college environments (Cummins, 2001). Expository science texts do not use the conversational style these students are taught in their English classes (Cobb & Horst, 2001; Cummins, 2001) and sub-technical words found in academic contexts present a unique difficulty to ELLs in addition to the biology-specific vocabulary (Cobb & Horst, 2001).

Learning to employ the 'jargon' of science detailed by Halliday (1993) presents a challenge because making meaning is an internal function, which makes it difficult to accurately measure a student's proficiency without demonstrating oral or written competency. This builds on Vygotsky (1987), who described how psychological tools such as language require students to express concepts in different ways across languages, thereby transforming their mental functions and compelling them to view the world in a different way. This internal process of transforming meaning is uniquely difficult for ELLs because of specialized vocabulary, sub-technical academic language and the new uses for conversational-level words (i.e. Periodic *table*, plant *class, school* of fish) (Carrier, 2005; Fang, 2006). These are conversational words that ELLs might be able to

decode, but may not be able to comprehend without explicit instruction in non-vernacular usage.

Scientific grammar consists of complex grammatical patterns that rely on nominalization (Halliday, 1993; Jaipal, 2001), or grammatical transformation that moves active phrases such as "*the results indicated strong plant growth*" to passive phrases where the noun is replaced with its verb form, such as "*the indication of the results suggest that plant growth was strong*." For English language learners, understanding how language use transforms meaning when it is shifted from conversational English clauses to academic English nominal groups requires a substantial act of internal reconstruction (Halliday, 1993). The nominalized, scientific form of discourse is unfamiliar to many ELLs, often requiring individualized instruction that content teachers may be unprepared to deliver (Carrier 2005; Cobb & Horst 2001; Jaipal 2001; Miller, 2009).

Halliday (1993) pointed out several other areas of confusion within scientific grammar that create problems for both ELLs and native English-speaking students, including lexical density and grammatical metaphors. Lexical density refers to the number of content-specific words used within a clause. This density varies greatly between unplanned, spoken English and planned, written English. "In informal spoken language the lexical density tends to be low; about two lexical words per clause" but written texts, such as high school textbooks, "tend to be somewhat denser than spoken language, often having around four to six lexical words per clause…and in scientific writing the lexical density may go considerably higher" (p. 76). This problem with

lexical density may be overcome by relying less heavily on written text and more on teacher talk, which was shown in Duran, Dugan, and Weffer's (1998) study to be a helpful technique for ELLs with strong oral comprehension. Oral language use may also reduce the confusion caused by grammatical metaphors found in scientific texts. A grammatical metaphor, as defined by Halliday, "is like a metaphor except that…it is a substitution of one grammatical class, or structure, by another" (p. 79). An example of a grammatical metaphor could be substituting the phrase "this resulted in homeostasis failure" for "homeostasis failed because of this." Halliday points out that, "for those who are taking up English…[confusion] may be greater or less depending on the degree and kind of grammatical metaphor found in [their home] languages" (p. 82).

In addition to these grammatical elements, the amount of written material that students are expected to comprehend in secondary science classes is staggering, especially when one considers that scientific grammar varies so much from the narrative texts used in literature and history classes (Carrier, 2005; Fang, 2006; Miller, 2009). Developmental ELLs are often novices in understanding procedural work, interpreting charts, and analyzing illustration captions for meaning (Duran, Dugan & Weffer, 1998). However, science texts for secondary students are written with the assumption that readers have had considerable experience in expository text scrutiny, independent reading skills, and understanding of analogies and metaphors (Santa & Alvermann, 1991), creating a disparity between what students *need* to comprehend and what they *can* comprehend.

This disproportion between need and ability is especially true when working with low-literacy ELLs. The specialized literacy needs of these students involve a great deal of understanding about how to incorporate language learning into the development of scientific inquiry. As Miller (2009) demonstrated in her study with African refugee students, content teachers are not often prepared to adequately support English language learners who cannot read grade-appropriate texts. Miller followed the progress of 23 eighth-grade students who had experienced disrupted schooling in Africa and did not have the literacy skills necessary to meet the demands of eighth-grade science texts. Miller speculated that students could demonstrate achievement, despite their limited science and literacy background, by scaffolding text with supplementary materials. Working with two ESL teachers and one science teacher, students were given a science text selection along with a glossary of key terms that were identified by the researchers. Students were also provided with worksheets, flashcards, and vocabulary card games created by the research team to scaffold the vocabulary demands of the science text. When possible, pictures were also provided as additional support. After learning with these materials, students exhibited below-grade results on the final assessment, but Miller reported that these results were still better than the science teacher had expected them to be, based on his past experience with low literacy immigrant students.

For students to be literate in science they must be able to communicate ideas and understand information unambiguously using vocabulary and grammar that is accepted by the greater scientific community (Rutherford, 1990). As demonstrated by the research on the language demands of science illustrated within this section, English language

learners are particularly vulnerable to the requirements of scientific texts and discourse because of their limited exposure to and proficiency with academic language. Without explicit awareness of the differences between academic/scientific English and colloquial English, students will have difficulty overcoming the formidable challenges presented in science courses. Research shows that students should be given multiple resources to learn difficult concepts and terms, in both academic and conversational styles, as a way to enhance their awareness of the gap that separates these two forms of English. The rapidly expanding field of mobile learning offers a way to engage learners in self-directed study by allowing them to repetitiously practice the academic and content language that presents obstacles in developing understanding of scientific concepts (Cavus & Ibrahim, 2009; Traxler, 2009). More information on mobile learning and its utility in language development is presented in the next section.

Mobile Assisted Language Learning (MALL)

Miller's (2009) study with African refugee students showed that providing materials to supplement learning can help ELLs achieve a higher proficiency in science. Mobile learning follows the same idea of supporting classroom teaching by giving students language-learning tools for independent study. Although many scholars have speculated on the value that mobile learning may offer, my search of educational databases showed that few studies have actually been conducted and published as of 2011. From this pool of data, some studies on mobile language learning are detailed in this section, followed by an analysis of two studies with particular relevance to my research on using iPods with ELL Biology students.

Mobile learning is an innovation in the academic world, so much so that its utility as a learning tool is overshadowed by its "celebrity status" as the next big trend in educational technology and distance learning. Mobile devices have become such a cultural norm that they cannot help but influence the way people learn (Kukulska-Hulme, 2009) but like all educational technologies, the technology itself is not the driving force behind pedagogy. Learning to surmount the novelty of mobile devices as learning tools will help educators see how they can become a feasible way to blend formal classroom instruction with informal learning opportunities.

Learning Outside the Classroom

Informal learning, as defined by Livingstone (2001), includes activities involving the pursuit of understanding, knowledge, or skill that happens without the presence of externally imposed curricular criteria. An example of informal learning outside the classroom can be found in Comas-Quinn, Mardomingo and Valentine's (2009) study that used mobile phones, digital cameras, and portable media players to allow a group of language students studying Spanish in Europe (n=8) the opportunity to travel around the city and communicate their learning experiences via weblog. Students were encouraged to actively practice their language skills in authentic settings that could not be matched in a classroom and then upload their new knowledge to share with their classmates. This small-scale study, like most of the studies involving mobile learning thus far, focused on the mobile learning method rather than the content itself (Traxler, 2009) and little detail was provided about what students learned or how it affected their overall language development. However, Comas-Quinn, Mardomingo and Valentine's study opened the

possibility of moving language experience outside of the classroom and allowing students to learn away from a teacher-directed setting. As mobile learning develops into an independent discipline within educational technology apart from computer-based learning, the learner will be emphasized over the technology being used (Brown, 2008). Furthermore, the addition of qualitative evidence about user habits, expectations, etc. to a field of primarily statistical data will help expand this learner-centered evolution. Chapter 4 of this report contains such qualitative data about my research into using iPods to deliver language study information for English language learners.

iPods and MALL

iPods are popular portable devices that have many functions traditionally found in larger-scale computers. iPods were originally created to serve as music playback devices, so it is no surprise that this audio utility has been capitalized upon for learning. Several studies, both formal and informal, have demonstrated how iPods can enhance reading and language lessons for students from a wide range of ages (Lacina, 2008; Patten & Craig, 2007; Ullman, 2010; Wei, 2008). In one study, Patten and Craig (2007) investigated how iPod audiobooks could be used to support reading and writing activities for high school ELLs. At the end of the study, students reported that they were more comfortable discussing texts and integrating higher frequency of complex vocabulary into writing assignments. Wei (2008) used iPods as supplementary devices for tutorial sessions with elementary school students and their tutors (n=6). Students were supplied with iPods that contained picture books that the tutors had narrated, recorded, and matched with the books. In between tutoring sessions, students were required to listen to the narratives as

they read and recorded their own narratives to show mastery. Students' oral fluency and expression was tested before and after the study and results showed that there was a 25% gain on average in these skills.

These studies illustrate that iPods, like other handheld mobile computing devices, have a role in the expanding field of mobile assisted language learning, even though a majority of MALL studies have used mobile phones as delivery devices. Evidence demonstrates that students respond enthusiastically to the technology, and this may correlate to improved academic achievement in some situations.

Chunking

Although mobile technologies have drawbacks (i.e. personal cost to students) they have many of the advantages of PC applications without the limitation of being tethered to a machine in a particular time and place (Chen & Chung 2008; Traxler, 2009). This allows the learner much more freedom in their learning—it can take place during a commute, a coffee break, or while waiting for an appointment (Kennedy & Levy 2008). By delivering content in small, easy-to-comprehend chunks, people can learn easily from podcasts, text messages, or other mobile applications (Habitzel, Mark, Stehno & Prock, 2006) that may otherwise lose their value if they were presented all at once.

Mobile assisted language learning, or MALL, emphasizes the utility of using mobile devices that many students already own and carry daily, to take advantage of small, unproductive chunks of time such as commuting to work or school, time between classes, or a lunch break. It requires that content be reconceived to fit a different mold, including limited space for communication (in the case of texting) and limited screen size

(for devices such as iPods). Language study is especially suited to mobile learning given that language study stresses repeated interaction with target vocabulary and grammar to achieve fluency (Cavus & Ibrahim, 2009; Traxler, 2009). An example of the benefit of using MALL was shown in research involving graduate students studying English as a foreign language in Japan (Stockwell, 2010). The researcher found that some students expressed preference for pursuing vocabulary review activities via mobile phones over PCs because the mobile phone was a more practical option for their lifestyle. Even though accessing the review activities via mobile phone took longer overall to accomplish, he concluded that students were better able to use "dead time" productively without infringing on time for other tasks. This conclusion blended with the "anytime, anywhere" theory that mobile learning brings to education by creating a new space where learning can occur away from a formal classroom or office.

The range of studies that have used mobile learning is considerable but, as demonstrated by my search of academic journals, the field narrows when focused only on language learning research. One such study conducted by Chen and Chung (2008) found that blending classroom learning with mobile device support is ideal for students studying languages because vocabulary comprises the building blocks necessary to gain understanding of sentences and vocabulary is always relevant, regardless of formal versus informal settings. Word study requires both time and exposure to target words but limited class time means that teachers are required to be selective about what they choose to cover (Thornton & Houser, 2005). Mobile learning delivery methods such as text messages, specialty applications, or mobile-friendly internet resources could provide

structured methods to repetitively reinforce vocabulary outside of classroom hours (Thornton & Houser, 2005). Using small chunks of time to present students with quick language lessons or reviews has been explored in studies around the world (Chung, 2005; Kennedy & Levy, 2008; Lu, 2008; Thornton & Houser, 2005). However, only two studies in particular relate closely to my research on using iPods to study biology vocabulary with ELLs; both are detailed in the following section.

Relevant MALL Studies

There are several studies that relate to this research on biology vocabulary learning for ELLs. Although my study does not directly originate from any of these previous studies, each related study demonstrates how using mobile devices as study tools could benefit students' vocabulary development, a key principle underlying my research design.

Two studies in particular impacted the design of this study on ELL vocabulary study. While neither Thornton and Houser's (2005) study using mobile email nor McGuigan and Weil's (2008) research using text messaging mention iPods, both focused on small, chunked language information meant to be consumed by students on-the-go. In this way, both pieces of research are closely related to my study using iPods as the information delivery device. These two studies both used mobile phones in place of iPods because they are owned and used more ubiquitously than handheld computing devices (Pew Research Center, 2010). This means that these two studies, like most MALL studies that have been conducted, explored mobile phones as the means of information delivery.

Mobile Email and Video

Thornton and Houser's (2005) three-part study with Japanese students of English capitalized on both mobile email and web-based videos to experiment with mobile language learning. The study began with a large sample of university students (n = 333) who completed a survey on their attitudes regarding mobile email use. The first phase discovered that all participants owned a mobile phone and that 99% of them frequently used mobile email.

The second phase involved a MALL experiment with a smaller group of 44 participants. Students were sent, or "pushed," short mobile email messages for two weeks. Each day they were sent a different lesson on a specific word and the same lesson was sent three times per day to encourage regular study and vocabulary growth of 10 words over the two-week period. To reduce redundancy, each message presented the word in a different manner. The morning message introduced the word and offered examples. The midday message rehearsed the word and placed it in context with other words being studied. The afternoon message used the word in a serialized story that also incorporated other target words. The messages were timed to correspond with morning and afternoon commutes as well as lunch, three time periods in which students could easily access their phones when they saw a new message had been received. The researchers were surprised to find that only 10% of participants read the messages at the time they were delivered, while 57% read all the messages only once a day, usually in the afternoon when they had time to dedicate to studying. Participants were surveyed at the end of this phase to gather their opinions on mobile email as a study tool. Ninety-three

percent of participants felt that mobile email was a valuable learning tool and 89% would continue to use it as a means of studying. However, given their message-accessing behavior, timing the messages to correspond with non-class time was not the optimal way of delivering the information.

The third phase of the study utilized both sending and receiving (or "push and pull") MALL features and involved 26 students divided into two equal groups. Each group was provided with a different delivery method to study the same target words over a two-week period. One group received "push" mobile emails sent by researchers at pre-set times with vocabulary information and the other group was encouraged to "pull," or independently navigate to a phone-accessible website where the vocabulary information was posted. Each group was expected to learn 10 words over the course of the study and learning gains were measured with pretest and posttest scores. The results showed that students who learned via push mobile email had significantly higher vocabulary growth than their counterparts who accessed, or pulled, the information via website. The researchers then extended this experiment by forming another mobile email delivery group (n=25) and a paper-based vocabulary list group (n=43) who had the similar task of learning 10 words in two weeks. The push mobile email group again showed higher gains from pretest to posttest, evidence that may suggest that users who received mobile emails from researchers were encouraged to study more than those who relied on the independent pull resources of a mobile website and paper lists.

Thornton and Houser's three-part study revealed several pieces of information that were unexpected by researchers. First, they were surprised that a majority of

students did not read the mobile emails that had been timed to correspond with commuting and lunch hours. They speculated that perhaps students preferred to access information on their own rather than having it pushed to them by teachers. In response, they set up both push and pull systems to give students access to vocabulary and were again surprised when the pull groups showed lower rates of language achievement than those receiving emails from teachers. These results illustrate that the students participating in Thornton and Houser's study preferred to receive information sent directly to them by researchers, but also preferred to access that information at times convenient to their individual needs. This is evidence that mobile learning, while largely independent and outside of the purview of classroom teachers, still relies heavily on the influence of those teachers, perhaps via electronic message, to ensure that students are maintaining their study habits. This teacher oversight is a human element that cannot be overlooked when providing an independent learning tool to students. Simply handing the tool over to students may not be enough to encourage its use; teacher influence must be used as additional encouragement to draw student's attention to the value of the tool.

Text Messaging

Although there were no studies that incorporated ELLs, biology, and mobile learning as of 2011, there was a study that used mobile learning as a vocabulary development tool for students lacking adequate background knowledge in a content area. McGuigan and Weil (2008) used a mobile phone-based program called StudyTXT to allow students access to basic concepts of first-year university accounting course. According to the authors, students who did not have a background in accounting often

struggled with fundamental topics in this course each semester and this tool was used to give them immediate access to learning support regardless of their location. The tool relied on students' technological competency and their familiarity with text messaging as a form of communication, but the researchers told students that, "there is nothing magical about StudyTXT. It is just a convenient version of traditional study notes" (p. 293).

The database of 101 messages included both vocabulary and conceptual knowledge divided into 22 modules. Messages in the database used abbreviated "text speak" to save space and keep messages as brief as possible. Students could choose which modules to access in order to tailor their studies and the texts, once downloaded to phones, could be forwarded to other students to develop knowledge collaboratively. Students were instructed on how to use StudyTXT and given a menu of different questions with a corresponding code for each question. If the student wanted to learn the answer to a particular question, they would text the appropriate code to a preset number that pulled the answer from the university's database and sent it to the user's mobile phone. The answer to that question then resided on the phone until deleted by the user. Each downloaded message cost $0.50 and complete sets of answers could be downloaded at a small discount. Students were encouraged to talk with their classmates and forward messages to each other to avoid these fees and stimulate the formation of small study groups. Students were also encouraged to "snack on study" (p. 289) by reviewing these questions and answers during small spaces of unused time during the day, such as their commuting time.

This study was implemented over one semester with a single section of Accounting 102 with 47 participants. Feedback about the course and the StudyTXT tool was collected via questionnaire at the end of the course. Twenty-six students completed the questionnaire, and approximately 80% of these participants were non-native speakers of English. Of the 26 students who completed the questionnaire, only 3 students had used StudyTXT, a fact that weakened the results of the study but did not diminish the preparation and methodology on the part of the researchers. This small group stated that they enjoyed the ability to plan their studies, which the authors speculated was due to the ability to select their questions that were of relevance to their studies. The questionnaire also showed that the text messages did not especially motivate students in the course and they did not form the small study groups the researchers had envisaged to exchange downloaded messages. The greatest discouragement to using StudyTXT, according to all 26 students, was the cost of receiving the text messages. Students also responded that the "text speak" used to write the answers was also a dissuasion to use.

This research broke new ground by understanding the utility of chunked language lessons for those requiring additional vocabulary instruction within a college course that was focused on a subject other than language learning. However, the small pool of willing participants and the lackluster reaction to the StudyTXT database demonstrated a limitation of mobile learning. McGuigan and Weil stated that learning vocabulary via mobile phone was not a magical solution to improving education. This is a key element to understanding the importance of their research. The significance of the mobile delivery device must be decided by the student, not the teacher or researcher that

develops the technology. If students do not choose to embrace the mobile delivery tool, as occurred in McGuigan and Weil's study, the reason behind such decisions should be explored and addressed by future research.

Language learning has long taken advantage of existing technology to deliver content (Kukulsa-Hulme, 2009), but the essence of language learning, according to Vygotsky (1987), will always remain the internal process of manipulating and reshaping meaning. Using mobile phones or iPods as content delivery devices adds new equipment to other technologies that have been adapted for language education, including telephones, audiotapes, CD-ROMs, and Internet-based tools, but simply adding a new device to the technology arsenal does not adequately demonstrate the power the device could have within a student's way of thinking. In each instance of technology adoption, user preference has played a role in the application of the technology for shaping curricula.

This user preference is the element that will be heavily explored within my research on ELLs learning biology vocabulary. McGuigan and Weil's participants noted that the cost of downloading the text messages and the "text speak" used to write them were both drawbacks to employing the texts as study aids. From this, it can be concluded that both cost and spelling barriers should be removed to increase the likelihood of student adoption of mobile learning tools. For these reasons, the mobile vocabulary tool used in my research was provided free of charge and did not use any spelling shortcuts that could be seen as confusing by students.

Summary of Influential Research

These two research studies provided significant background for the planning and execution of my own study. Thornton and Houser's research showed that students would likely adapt the tool to fit their schedules, so it was important to construct a tool that allowed them to access information at any time. It also demonstrated that teachers should continuously promote the tool as a study option so that students are reminded to use it. McGuigan and Weil's research illustrated that the tool should not add to students' financial or linguistic burden by requiring a fee or excessive time to translate. While these studies both had limitations, including small sample sizes and usage of questionnaires rather than detailed interviews to gather qualitative information, they provided a useful foundation by showing areas to promote and avoid during my own research.

Both McGuigan and Weil's and Thornton and Houser's studies concluded that mobile language learning research was still in its infancy and more had to be done with larger samples of participants. Although my study did not use a large sample, it capitalized upon previous studies by adding a greater voice to student and teacher experiences than the questionnaires used by these two studies. The addition of these narratives from qualitative interviews may inform future studies when considering design, sample population demographics, and other important factors.

Connection of Literature Review to Research

The studies in this chapter provided the foundation for my investigation into understanding the perception of a mobile vocabulary tool as a review instrument within

an ELL Biology class. The literature shows that these lines of inquiry—independent study behaviors, science-based academic language, and mobile language learning—have not intersected before. My search of academic journals revealed that, as of 2011, there have been no studies that encompassed these three areas for students at any grade level. As stated in Chapter 1, English language learners are a carefully scrutinized group under NCLB and their academic performance on standardized science exams has consistently fallen behind that of other subgroups. This indicates that research on helping ELLs reach parity with other subgroups will become a priority for educators and policymakers. To reach that parity, a curricular emphasis on scientific vocabulary and grammar must be established that fits the unique language needs of ELLs coming from multiple linguistic backgrounds into English-only classrooms.

The literature also shows that mobile learning, specifically in the area of language learning, is expanding. The technology that makes this possible already exists in the form of mobile phones and iPod-style devices. Researchers are discovering ways to adapt these consumer electronics to fit the educational needs of students whose on-the-go lifestyles allow them to be more flexible with when, where, and how they choose to learn. The most relevant studies published so far (McGuigan & Weil, 2008; Thornton & Houser, 2005) have had limitations in their design, such as the small number of participants in McGuigan and Weil's StudyTXT research and the teacher-centric control in Thornton and Houser's mobile email study. It will take the efforts of other researchers to reproduce and expand these studies to understand the true value of their conclusions.

Given that the literature covering my three main areas of research have not intersected before, it was imperative that my study should add to the body of research in a meaningful way. As noted before, questionnaires were the primary means of collecting data from several studies described in this chapter (Grabe & Seigler, 2002; Johnson, 2007; McGuigan & Weil, 2008; Nonis & Hudson, 2010; Thornton & Houser, 2005), while others relied heavily on researcher observations within a classroom setting (Carrier, 2005; Duran, Dugan & Weffer, 1998; Jaipal, 2001; Miller, 2009). Expanding on these questionnaires and third-party observations, I used qualitative interviews with both student and teacher participants, which allowed insight into the reasons behind why ELLs perceived, and therefore chose to use or not use, the tool as a means of independent study. This qualitative approach gave voice to participants which helped me comprehend the rationale behind individual perceptions of MALL technology and its utility in learning complex scientific vocabulary.

3. METHODS

This chapter explains the specific methods supporting this study. It provides details about the mobile vocabulary tool, participants, setting, and data collection procedures. It concludes by explaining the type of data analysis that will be used.

This study was an investigation of student and teacher perceptions from introducing an iPod-based vocabulary review tool into the study habits of intermediate English language learners in an ELL-only Biology class. Two research questions were examined:

RQ 1: How did these ELL Biology students perceive the iPod-based vocabulary tool as a means of informal study?

RQ 2: How did this ELL Biology teacher perceive the effect that the vocabulary tool had on her students' learning behaviors?

As demonstrated by the literature, the MALL studies using mobile devices for informal, independent study employed questionnaires to gather feedback from participants. In McGuigan and Weil's StudyTXT research (2008), 26 students completed the post-study survey, but only three of those students had used StudyTXT throughout the semester. Thornton and Houser's (2005) study using mobile email and videos to deliver vocabulary information to participant's phones used a variety of larger samples, but the depth of the survey questions did not allow students to offer nuanced opinions.

Participant voice has been underrepresented in the discourse on ELLs learning science (Carrier, 2005; Miller, 2009). The two research questions that form the nexus of this study added greater participant voice to the body of literature that encompasses MALL, second language acquisition, and science education. Both questions were intentionally broad, a conscious decision made to allow for a wide range of opinions from participants. The methods described in this chapter were used to convey this population's "story of learning" so that educators and policymakers may have a greater understanding of how mobile technology can impact students' academic development

Mobile Vocabulary Tool

The mobile vocabulary tool was a free program provided to students for any iPod Touch or iPhone. During interviews, students referred to the mobile vocabulary tool as an "app." Of the 13 participants, 8 students owned these devices and 5 did not. No devices were provided to those students without one. I encouraged, but did not require, students to use this vocabulary tool as a review mechanism for preparing for the state biology proficiency test required at the end of the school year.

The mobile tool contained a database of approximately 250 multiple-choice questions that focused on vocabulary words specific to biology content. Formatted to mimic a trivia game, each round consisted of ten questions pulled at random from the 250-question database. The question database was provided by the ELL Biology teacher during the early planning phases of this research. Examples of the types of questions used can be located in Appendix B and C. Examples of the mobile tool design and interface is located in Appendix D.

Students were shown each question along with four answer choices and had 15 seconds to choose an answer. If a student chose incorrectly, the correct answer was indicated before the next question appeared. Points were given for answering both correctly and quickly.

Description of Methods

This study was designed to capture the richness of student and teacher experiences through qualitative interviews (Weiss, 1994). As demonstrated by the gaps in existing literature, using mobile technology as a tool for studying science vocabulary in ELL populations had not been heavily researched. This study sought to generate an understanding of whether a mobile vocabulary tool had an effect on student perception and study habits, as well as teacher perception of observed learning behaviors.

Design

The first research question sought to discover student perception of an iPod-based vocabulary tool as a means of informal study whereas the second research question relied on the teacher's perception of learning behaviors by ELLs in her biology class. These questions were answered using interview data to form a qualitative interview study with multiple participants. Unlike an ethnographic study, interview studies do not require extended field research, nor do they require participant observation, which will not be possible in this study due to the intermittent and individualized nature of mobile learning. Instead interview studies are often used when "how" and "why" research questions examine a contemporary issue over which the researcher exerts little or no control (Yin, 2004). For this research, learning via iPod was informal and using the study tool was

entirely at the will of student participants. Learning the possible reasons for using this tool qualified as ideal ground for a qualitative interview study design that may serve to influence non-ELL specialists such as educational administrators and policymakers.

Setting

The setting of this study was a large suburban school district located near a major metropolitan area of the Mid-Atlantic region of the United States. This district had a total population of approximately 170,000 pupils and a great deal of linguistic diversity, with immigrant students representing approximately 100 different languages. The Federal Graduation Indicator showed that approximately seventy percent of students with limited English proficiency graduated within 5 years of entering high school.

All participants in this study were enrolled in a single high school within this district. The school had a population of 2,050 students, of which 9% qualified for free or reduced lunch. Three percent of the student population at this school received specialized ELL services, but 8% of students were classified as Limited English Proficient. This disparity was due to a number of factors. First, students who received ELL services in lower grades but received sufficient scores on the statewide English language proficiency assessment to exit the program may still have been qualified as LEP for up to 2 years after exiting. This disparity also reflected LEP students who were enrolled in Special Education and received no specialized ELL language instruction, as well as students who chose to enter mainstream classes without any ELL support services. ELL support services included ELL-only classes in several disciplines, including language arts, social studies, and science, as well as special accommodations such as extended time for

completing tasks and the use of dictionaries on formal assessments. ELLs at this school have had a higher pass rate on the state biology exam than the state average, but students with limited English proficiency still struggled with acquiring the content vocabulary, a problem that affected this language subgroup in general.

Participants

Participants in this study had been enrolled since the beginning of the school year in an ELL-only biology class that was not labeled with a special title in the school, but will be referred to in this study as the ELL Biology class. There was only one ELL Biology class at this particular school due to the small ELL population.

Participants for this study were identified by the school district as intermediate proficiency English language learners based on their composite scores from the statewide English language proficiency assessment. This particular state uses the World-Class Instructional Design and Assessment: Assessing Comprehension and Communication in English State-to-State for English Language Learners (WIDA ACCESS for ELLs) commonly referred to as the WIDA test. The ELL Biology class was composed entirely of students who had been identified either as intermediate or advanced level English proficient learners. Advanced level ELLs were also identified by their scores on the WIDA test. Although the class was comprised of mixed levels, only the intermediate students participated in this study. This distinction was made of necessity because of my position as a teacher of advanced level ELLs at this school. To reduce potential validity threats or conflicts of interest, no advanced-level students were asked to participate in the research, although they had the same access to the iPod-based vocabulary review tool.

There were 15 intermediate students in the ELL Biology class from a variety of linguistic backgrounds. Thirteen students chose to participate in the study. All 13 students were between ages 14 and 18.

Eight of the 13 participants owned either an iPod Touch or an iPhone and five did not own either. Both devices were acceptable for use in this study. Students were encouraged to participate in this study, whether they had an iPod or not. iPods were often shared among friends during non-academic periods such as lunchtime and bus rides, so even non-iPod owners played the game. All students, regardless of ownership, reported using the vocabulary tool at least 3 times during the data collection period. The table below summarizes the demographic information of all 13 student participants.

Table 1 Student Participant Demographics

Student Alias	Age	Gender	Home Language	Years in the U.S.	iPod/iPhone Owner
Student 1	15	F	Nepali	1	Yes
Student 2	17	M	Urdu	2	Yes
Student 3	16	F	Spanish	3	No
Student 4	15	F	Spanish	2	No
Student 5	15	F	Spanish	4	Yes
Student 6	16	M	Chinese	1	Yes
Student 7	16	M	Korean	1	Yes
Student 8	16	M	Korean	1	No
Student 9	18	M	Spanish	2	Yes
Student 10	15	M	Uyghur/Japanese	1	Yes
Student 11	17	M	Turkish	2	Yes
Student 12	15	M	Spanish	3	No
Student 13	14	F	Korean	1	No

The instructor of this ELL Biology course also participated in this study as a source of qualitative interview data. She was a veteran teacher who had been instructing biology classes for several years. Her linguistic background was Spanish and she held both a B.S. and a Ph.D. in science. She had been teaching at the site school for six years and taught both the ELL Biology class and AP Biology. She was identified as a participant for this study because she was the only instructor of this ELL Biology class at this school.

Data Collection

Data for this study were collected in the form of weekly questionnaires, interviews, vocabulary tests, researcher fieldnotes, and informal conversations. Interviews were conducted at both the beginning and the end of the study. Post-interviews included some questions formed from data gathered from questionnaires and vocabulary tests during the study.

Weekly Questionnaires

Short questionnaires were distributed to student participants each week. These questionnaires asked them to estimate the number of times they played the day before, and then asked them to judge if that number was a general representation of the frequency of their vocabulary tool usage for the week. The questionnaires also asked participants to report any positive or negative feedback about the vocabulary study tool. This information was used to produce individualized interview questions for use in the final individual interviews.

Vocabulary Tests

Multiple-choice vocabulary tests were administered to intermediate ELLs in the ELL Biology class at the beginning and end of the study. These tests can be located in Appendix B and C. Questions on these tests, in addition to providing information for the study, also illustrate the types of questions used within the mobile vocabulary tool.

The purpose of these tests was to provide potential supplementary evidence that was used to inform post-study interview questions. For example, one student who showed a significant increase in correct answers between his pre and post vocabulary tests was asked to describe what he did to achieve such results. Another student who insisted that he studied regularly but showed no gains between the two vocabulary tests admitted that perhaps his study time, although regular, was not as rigorous as it could have been. Due to the small number of participants and lack of an adequate control group, these tests were not used as statistical evidence of vocabulary gains over the duration of the study.

To ensure that the vocabulary test contained ecologically valid questions that addressed specific and appropriate biology vocabulary, common assessments used by the school's science department at the end of each unit were examined. These multiple-choice assessments were created by the school's science department and covered fundamental knowledge of each unit of study. Forty questions that focused on vocabulary knowledge were chosen from these common assessments and used to form the pre and posttests. The pre and posttests therefore served as hybrids of assessments that students had taken throughout the school year. Although use of a multiple-choice

instrument can reduce the validity of results by allowing participants the chance to guess correctly (Webb, 2008), this arrangement closely mirrored the format the students were used to encountering on formal assessments of science knowledge. This format also reduced the potential for errors in spelling and syntax that may have inhibited ELLs from accurately conveying their science understanding during assessments (Shaw, 1997).

Interviews

This research sought to capture the experiences of participants whose limited English proficiency may have prevented them from precisely conveying their opinions. Using open-ended interview questions pre and post the data collection period allowed for clarification of ideas and flexibility to understand "nuances of language" (Mears, 2009, p. 48). To properly find these nuances, I was careful to avoid asking leading questions while simultaneously encouraging participants to describe their experiences using descriptive stories and anecdotes (Weiss, 1994). Questions that were used in both the student and teacher interviews can be found in Appendix A.

Given the wide cultural and linguistic backgrounds of this group of ELLs, it was important to collect firsthand experiences to piece together a collective ELL 'story' of learning as well as a teacher 'story' of teaching. Understanding individual points of view was integral to the value of this research and enhanced the objective of increasing an under-populated intersection of research between the discourses of language acquisition, science learning, and educational technology.

Student interviews. Student interviews at the beginning of the study, referred to as pre-interviews, were used to 'set the scene' by gathering data about students' past

experience with science learning, their study habits, and their familiarity with technology. These three factors provided insight into how students previously learned science in their academic careers before beginning the ELL Biology course. All interviews were audio recorded, transcribed, and analyzed using NVivo 9 qualitative analysis software.

Student pre-interview data collection. The research focus for the pre-interviews was to gain an understanding of student "stories of learning." Pre-study interviews were completed either individually or in pairs, depending on student preference, from March 23 to April 5, 2011. Most interviews were conducted on site after school hours, but several took place during class time when teacher permission was granted. Interviews were semi-structured to allow for flexibility of individual experience and language ability. Students were each asked 7 primary questions with expansion questions added based on their answers. Interviews lasted between 24 and 52 minutes depending on the number of expansion questions and the length of student responses.

Student post-interview data collection. Post-interviews were also conducted at the end of the study, approximately 8 weeks from the start of data collection, from June 1 to June 7, 2011. Students were allowed to choose if they wished to be interviewed individually or with a partner. Post-interviews included tailored questions towards students who had various levels of experience with the game, ranging from no use to frequent use. These interviews also allowed me to use a student's responses from the beginning of the study to ask follow up questions about study habits or perception.

The data collection and analysis process for post-interviews followed the same method used with pre-interview data. Students were asked about their perceptions of the

mobile vocabulary tool as a means of informal study. This tool was 1 of 4 review options available to students in the ELL Biology class before the state mandated biology proficiency exam. Other options included independent study, after-school review sessions, and online quizzes using released questions from previous state biology exams. Two student participants withdrew enrollment from the site school before the end of the end of data collection period and did not complete post-interviews.

Teacher interviews. Given this particular school's history of achievement on state standardized tests among ELLs studying biology, it might have been assumed that ELLs at this school did not suffer from the same challenges faced by ELL biology students at other schools. However, allowing the ELL Biology teacher to add her voice to the data offered a way to challenge this assumption. This teacher had a unique position as both a scholar and a second language learner and therefore her insights into using second language acquisition pedagogies provided a more complete picture of the day-to-day challenges of her ELL Biology students. Conducting both a pre-interview and an post-interview using open-ended questions with this teacher provided important data on the behaviors and challenges of ELL Biology from an instructor's perspective, as well as a teacher's observations of her students' learning behaviors.

Gathering interview data from the teacher of this ELL Biology population added a degree of insight that is rarely found in research on ELLs in science. Miller's (2009) study in teaching science to refugee students used interview data to provide a collective teacher voice that effectively conveyed the frustration felt by mainstream teachers with little experience in second language acquisition pedagogy. The addition of this 'human

dimension' was necessary to understanding why a school that showed seemingly few problems with achieving high pass rates on state tests may still have faced internal learning struggles within an individual classroom. To leave out the voice of this teacher and her perspectives on ELLs, biology, and technology would have presented an incomplete picture of this particular research site.

Teacher interview data collection. Information provided by the biology teacher during her interviews remained completely separate from data collected from students. This was due to the different types of questions asked of the teacher about her education philosophies and practices that did not correspond with student interview questions. She was asked to discuss her teaching background, scientific vocabulary, challenges associated with teaching ELLs, study methods, and instructional technology, as well as her impressions of the mobile vocabulary tool's effect on student learning habits.

The ELL Biology teacher's pre-interview was completed on April 25, 2011 and lasted approximately 1 hour. Given that there was only one teacher participant and one point of view, it was not possible to search for common themes across participants as was done with the student data. Instead, the teacher's interviews were closely re-read multiple times to find strong themes that stood out in her descriptions of teaching practices and philosophies. The post-interview was conducted on June 16, soon after the ELLs had taken the state standardized biology test. It was supplemented by informal conversations held throughout the data collection period and recorded in fieldnotes.

The ELL Biology teacher at this school had given presentations at both county and state-level workshops about working with ELLs to master science content. She had

already reflected on her best practices and was able to converse about them easily during her interviews. It was clear from her responses that she had specific methods for teaching English language learners that did not correspond with more traditional vocabulary-focused techniques used in many science courses with ELLs (Carrier, 2005; Rutherford, 1990).

Fieldnotes

Fieldnotes were used throughout in the data collection process. The reasons for this were threefold. First, the period for gathering data was three months long. Notes from the beginning of the study that captured my reflections were extremely helpful for memory stimulation during the final data analysis that took place several months later. Fieldnotes also helped record the atmosphere of each interview and my impressions of the participant's feelings. Finally, notes helped to shape my overall research design, which was an ongoing process where collected data acted as supplementary information for forming post-interview questions (Maxwell, 2005). Because my data analysis was a progressive process, these notes offered valuable guidance in identifying shared themes across interviews.

Informal Discussions

Throughout the 8 weeks of data collection, I had multiple opportunities to discuss individual students' progress in biology both with the students and their biology and English teachers. These discussions were often spontaneous and unstructured. Most discussions with teachers focused on students who were performing poorly in biology, which allowed me to offer feedback and encouragement to these particular students when

I saw them in passing. With all students, the same advice was offered: attend the after-school review sessions and use the online quizzes as well as the mobile vocabulary tool to study specific questions. I also had multiple opportunities for informal conversations with the ELL Biology teacher during faculty meetings and planning periods. These informal discussions allowed me to gather a better understanding of specific students' needs and instructional problem areas, giving me insight into student learning behaviors that may not have been discussed in interviews.

Data Collection Timeline

Data collection for this study took place over a period of 3 months in the final quarter of the school year. This time period was chosen because it was a review period for the biology class, which paralleled the intended function of the mobile vocabulary tool.

Students

After receiving study approval from both the university and the school district HSRB offices, student participants were presented with consent/assent forms during their intermediate ESOL class at the end of third quarter. Both the forms and the study were presented at that time and students had the opportunity to ask the researcher any questions. This presentation took approximately 20 minutes to complete. In their ESOL class the following week, students were asked to sign up for individual or paired interview times, which were held after school for 2 weeks. The pre-study vocabulary test was administered on the same day as interview signups and took approximately 25

minutes to complete. After the tests were collected students with iPods were shown how to download the vocabulary study tool to their devices.

Participants received weekly questionnaires 7 times over the following 8 weeks (with one week off for spring break) during their intermediate ESOL class period. These brief questionnaires required less than 5 minutes to complete. The total time for each participant to complete all questionnaires was 35 minutes over the course of 7 weeks.

Final data collection began the first week in June. The post-study vocabulary test was administered during the intermediate ESOL class period. The first week of June was also the beginning of post-interviews for participants. Again, students were given the choice of being interviewed alone or with a partner. The total time requirement for each participant was under 4 hours over the course of the study. All data collection for the study was complete by the third week in June.

Teacher

Interview data from the ELL Biology teacher was collected using approximately the same timeline as the student interviews. The teacher was presented with a consent form and study explanation at the end of the third quarter and was interviewed for approximately 1 hour after school three weeks later. She was interviewed again at the end of fourth quarter, also for 1 hour.

Data Analysis

Primary data for this study were gathered from interview transcripts. These were supplemented with information taken from weekly questionnaires, vocabulary tests, and informal discussions.

Student pre-interview data analysis

The pre-interview questions addressed to students sought to discover individual student experience in four areas: 1) science background from school in their native country, 2) study habits, 3) attitudes about biology/science learning, and 4) familiarity with technology as a study aid. These areas later became the organizational coding nodes after transcripts were loaded into NVivo 9. Establishing an understanding of individual students' experience in these areas formed a baseline for comprehending their learning behaviors, which influenced individual perceptions of the mobile vocabulary tool at the end of the data collection period.

Using NVivo, interviews from 13 students were sorted into 5 initial organizational categories. The study habits node was divided into general study habits and vocabulary study habits once I realized that the interview questions distinguished between these 2 areas. After reading the transcripts numerous times, similar themes emerged within and among these nodes as student data were consolidated and reduced. Overlaps and redundancies were collapsed into more meaningful, substantive nodes based on participants' words and expressions rather than the organizational coding. These second-stage categories, or free nodes, were expressed with substantive codes taken from student quotes.

Student post-interview data analysis

Data analysis for the final 11 student participants followed the same procedure as the previous interview analyses. Interviews were transcribed, re-read multiple times, and loaded into NVivo for coding. These interviews focused mainly on perception of

personal experience using the mobile vocabulary tool and 3 discrete nodes were developed from responses: 1) perceptions of the tool itself, 2) perceptions of the tool's helpfulness, and 3) ways in which the tool was used by students. As before, student responses were used to both form and label each node/theme extracted from the interviews.

Teacher interview data analysis

Transcribed data from both teacher interviews were coded into 5 organizational nodes based on her responses. These nodes were: 1) high expectations, 2) the skills needed, 3) explanations, 4) in context, and 5) perceptions of the mobile vocabulary tool's utility. As with student data, these nodes were extracted from the participant's own words. Each of these categories detailed a unique component of her instructional values and beliefs that directly impacted her ELL students' knowledge of biology content. These components are described individually and together in the teacher's "story of teaching" in Chapter 4.

Coding

Each participant interview was transcribed and analyzed individually before beginning to cross-reference participant responses for broad themes. Although several organizational categories were evident in the student interview script such as Technology, Science Learning, and Study Habits, these categories did have much relevance once the narrative distillation process was complete. Open coding was the primary means of categorizing patterns of thought across participant transcripts (Emerson, Fretz & Shaw, 1995). Substantive categories were drawn from repeated themes among the transcripts

and formed into a participant/substantive category matrix. Using participant's own words to label themes ensured that the codes came from the interviews, not my preconceived ideas as a researcher looking for passages to support my own ideas. The matrix format provided necessary organization to better visualize how responses from different participants worked together to form collective accounts of learning behaviors. There were several different connecting strategies available that helped support my data, including the construction of story of learning/teaching vignettes (Maxwell, 2005). Decisions on connecting strategies were ongoing throughout the data analysis phase.

Narratives

Using "excerpted narratives" (Mears, 2009, p. 131) was a method to show connections among participant responses. These narratives were formed by distilling each participant's transcribed responses into poetic form in order to achieve a deep understanding of individual perspectives. I also used my interview notes and informal conversations as additional references to best portray participant understanding.

Mears describes the steps of the distillation method in detail; I used her description as a guideline for my own narrative-distillation process. She suggests that the researcher start by searching for repeated phrases and themes within and across narratives, similar to other qualitative analysis techniques. As I analyzed the interview data, I discovered repeated themes, which I catalogued using NVivo. Once I had collected relevant sentences and passages supporting the themes, I re-read them carefully and removed non-essential words that did not aid meaning, such as transition words and

vocalized pauses. I focused on creating fragments of sentences, or poetic phrases that conveyed a speaker's essential meaning without the encumbrance of unnecessary words.

Once essential sentence fragments were identified, NVivo was used to list them to resemble a long-form poem rather than a paragraph. Because I chose to "cut, delete, purge" (p. 125), it forced the remaining words to carry powerful and critical communication unburdened by wordiness. Mears also recommends changing grammatical word forms or replacing nouns with pronouns to create a better flow of understanding in linking phrases. These changes helped to communicate the participants' responses to the research questions more clearly.

Limitation of the Study

A limitation of this study was that the research site was atypical due to its extremely high pass rate (100%) for the ELL biology class on the state biology exam for the previous several years. The average pass rate for ELLs in the state was 72% (Virginia Department of Education, 2009). For this reason, state test exams were not a measure of success or progress with these students and data instead focused on individual participants' perspective.

This school may have appeared be a poor choice due to the exceptional pass rate. But having worked at this site for years, I knew that the ELLs studying biology there had the same issues in learning biology vocabulary and content that had been documented by research detailed in the literature review. This limitation may have affected the transferability of the findings, but the qualitative interview design still allowed research-

based information to be accessible by parties unfamiliar with mobile learning, English language learning pedagogy, and science (Yin, 2004).

Validity

Reflexivity

The most prominent validity threat facing this research was that it was conducted at the school where I was employed as a teacher. Although I was not a teacher of record for any of the participants, I had developed relationships with several of the students, either because I taught them in the past or I worked with them informally in the course of performing my teaching duties. This was not quite "backyard research" as defined by Glesne (2006) because I was not working with my own students, but it did bear some relation to it. Having a previous teacher-student association with some students may have either helped students speak honestly during interviews or caused them to withhold opinions for fear of possible repercussions. I believe that my positive relationship with these students was an asset to this research rather than a threat to validity because a teacher speaking with students about study habits was entirely within the realm of day-to-day teaching and learning. Although it is also possible that students gave positive responses that they thought I would like to hear rather than voicing their true opinions, I heard enough negative responses that I was confident the students were choosing to speak honestly.

In order to limit reactivity among participant responses, it was essential to reassure all students that their comments and ideas were confidential and their interview responses would not be transmitted to either their English or biology teachers. It was also

my responsibility to ensure that student participants knew that their study behaviors and interview responses would not affect their grades in any way. Furthermore, each participant was made aware that their statements would remain anonymous in the reported data.

Language Limitations

The idea that participants' language proficiency may have limited their ability to articulate their feelings could have been a hindrance to extracting their authentic feelings about their experiences. I was careful to constantly seek clarification of meaning during the interview process. By asking interviewees to expand upon their statements with more detail or give examples that showed precisely what they meant, ambiguity caused by lack of fluent vocabulary was reduced. Another method for reducing ambiguity of meaning was to restate the interviewee's words and seek confirmation of accuracy.

Study Tool Design

The vocabulary tool used in this research was originally designed for entertainment, not learning. Students could not self-select units they wanted to focus on nor could pictures, graphs, or charts be used due to software limitations. A better tool would offer a menu of units and the option for students to turn units off/on. This would better fit with the constructivist perspective of providing a clear, established structure that students can work within to allow them to explore material at the pace and sequence they prefer (Shaw, 2001).

Study Tool Development

As noted in Chapter 1, the development of the vocabulary study tool was driven by my actions. I was involved with recruiting the application developer and creating a database of biology vocabulary questions to be used within the application. Having no background in biology, I turned to the ELL Biology teacher to create questions on content I was unfamiliar with. The resulting questions database was a product of our collaboration. The ELL Biology teacher was therefore already aware of the tool's existence, but also of its limitations. To reduce any potential threats to validity, neither myself or the ELL Biology teacher disclosed any personal involvement with the study tool to students enrolled in the ELL Biology class.

4. FINDINGS

The purpose of this study was to discover user perceptions of a mobile tool for learning biology vocabulary within a small group of intermediate-proficiency English language learners. Thirteen students from 10 different countries participated in the study. These 13 students represented seven different language backgrounds, including Chinese, Korean, Nepalese, Spanish, Turkish, Urdu, and Uyghur/Japanese. One teacher, a native Spanish speaker, also participated in this study. All students who participated were classified as intermediate ELLs by the WIDA assessment administered by the state board of education.

Qualitative analysis and research findings to the following two research questions are presented in this chapter.

RQ 1: How did these ELL Biology students perceive the iPod-based vocabulary tool as a means of informal study?

RQ 2: How did this ELL Biology teacher perceive the effect that the vocabulary tool had on her students' learning behaviors?

Qualitative data extracted from participant interviews are organized in two parts. The first part derives from student data about their general perceptions of learning as well as data that specifically pinpoints student perceptions of the mobile vocabulary tool as a means of review leading up to the date of the standardized biology proficiency exam.

The second part consists of data from the teacher, which is intended to complement student perception from the perspective of an educational professional with ELL teaching experience.

Findings From Student Pre-Interview Data

In the pre-interviews, students were asked questions about their educational background in science, their methods of studying, their opinions of biology class, and their employment of technology to assist learning. From these questions, four themes emerged that were repeated across multiple interviews. These themes comprise students' initial "story of learning," a mixture of their personal experiences of school in their native countries and their techniques for mastering demanding science content in an American school setting.

It's a Different Language

Students were never explicitly asked about transfer of content knowledge from L1 to L2, but several participants raised the topic during interviews by referring to biology vocabulary as "a different language." Some students expressed that they were familiar with biology content from school in their native countries, but others had little to no understanding of biology before taking it in their American high school.

> (Student 13) *I can understand in Korean*
>
> (Student 1) *You may already know the words from somewhere else*
> *The words are kind of same in biology but not always totally the same*
> *If you know the word from your language then you can find help in English*

Although familiarity was helpful for some, one participant stated that previous knowledge was more of a hindrance than help.

(Student 9) *I knew everything just the language is different*
I can understand everything in Spanish
When I take a test
I just got stuck on one word
What does this mean?
I look in dictionary
Doesn't help
I find this word, I don't know this word
And I just keep going

Two participants viewed scientific biology vocabulary as a separate language from either their native language or English. They characterized biology as an L3 that frustrated them because it was difficult to transfer anything relevant from either their L1 or L2.

(Student 10) *I can't read the vocabulary in biology*
It is not like English
In English, I don't know the word but I can guess the meaning
It's like a different language

(Student 9) *When I am looking at the book there are too many words*
Then I am saying what does this word mean?
Then I have to get my dictionary and look for it
I am just wasting my time

Students were asked to compare learning biology words to learning vocabulary for world history. Eleven of the 13 participants replied that the vocabulary in their biology and world history classes carried the same level of difficulty and their study methods did not distinguish between the two subjects. The 2 students who viewed biology vocabulary as an L3, despite their frustrations with language transfer, thought that the world history vocabulary was more difficult because it lacked the precision of science terminology.

(Student 10) *History vocabulary is like English*
I can guess the meanings if it is a name or something
The biology vocabulary has a clearer meaning
That is why it is different

(Student 9) *You have a little small word and all these things, like definitions in the [history] book*
Then when you have the [history] quiz it is a whole different definition
It's not exactly the same as in the book

Research has shown that English language learners may not be able to simply transfer content knowledge between languages, either because they have no content knowledge in their L1 or because concepts do not transfer clearly (Carrier, 2005; Jaipal, 2001; Rutherford, 1990). This concept is demonstrated by these interview data that show students' struggle with merging knowledge gained in the past with present-day requirements.

I Don't Have to Try to Understand

Students were asked to recall their memories of formal learning and study habits before they came to the United States. Student responses about their personal study methods combined elements from their educational backgrounds, language abilities, and technology utilization to create a mixture of learning strategies that helped them meet challenges in their biology course. Reliance on rote memorization pedagogy was a repeated theme found in all student responses.

Participants were specifically asked about any memories of science classes in their home countries but some students discussed other subjects as well. Students recalled school practices that varied significantly from the expectations of their suburban, Mid-Atlantic American high school. They shared that their classroom environments were often teacher-centric, with few science experiments or chances at collaborative learning. Several mentioned that they had little to no access to a science laboratory classroom or basic tools such as microscopes.

(Student 10) *We were learning straight from the textbook*
Here in [the ELL Biology] class we do a lab at least once per week
But in Japan it was not like that

(Student 4) *He didn't explain things*

(Student 3) *She didn't really teach us things*
She just went to the class
Just was like talking, talking

Only 5 students recalled performing laboratory work before beginning the ELL Biology course. They described their previous work as far less detailed than the work in the ELL Biology class. These narratives show that students were not only unfamiliar with the biology content and equipment, but they also had fewer experiences in discovery learning via laboratory experiments. Such lack of experience could have had an effect on their individual study habits if they were unprepared for the level of detail they were expected to provide to show proficiency in the ELL Biology class.

Reliance on the textbook as the main source of information was also repeated by many of the student participants.

(Student 13) *She just read little book to us*

(Student 12) *In science we had chemistry, biology and physics in one book*

(Student 2) *We would have to find the answer in the book in three to six paragraphs*
We did not get much information

(Student 4) *He gave us books to copy and copy and copy*

(Student 6) *Copy it out*
Every subject just read it
Don't have to try to understand

Student participants shared many similarities in the way they chose to study for ELL Biology content outside of class time. Memorization was the study skill most often cited during interviews to illustrate students' current personal study habits. Participants described different ways to commit information to memory, including reading the class textbook and notes aloud, keeping notes about relevant information, or making visual contact with materials.

(Student 3) *I just read it and read it to memorize it*

(Student 12) *Just read the paper a dozen times or as many times as I feel like it*
The image gets stuck in your mind

(Student 7) *I stare at [the vocabulary words]*
Just waiting to when the information comes
The image comes in my head

(Student 4) *I read aloud by myself*
I take notes from the most important things that I find in the book

(Student 3) *I try to read sometimes out loud*
I think that it works better when you read science
Then it is better to read it out loud so that you can memorize

The techniques they described were the same whether students were discussing memorization of biology concepts or vocabulary. They did not recognize a difference between learning words or concepts, perhaps because of the ELL Biology teacher's habit of teaching technical vocabulary in context of the entire lesson.

(Student 11) *My sister said to write all of them again, it might help*
So by copying maybe that is helpful, it is easy to learn for me
I just write the word and the meaning like ten times on a page
One word in English and then the translation in Turkish

(Student 3) *I write down the words and I write the definition*
I try to read it a lot of times
In one paper, like all definitions

Most students had a difficult time describing their methods of study in detail. This may have been due to limited English proficiency or unfamiliarity with reflecting upon their actions. Only 1 student was able to describe her mental process for learning new words.

> (Student 4) *When I am creating the definition, I look for 'a special word' that*
> *Makes me remember that word*
> *A 'glue'*
> *Like a synonym*
> *If it has a synonym then it might be easier to remember*

Participants' descriptions of their learning strategies showed a shared theme of memorization with only one participant who was able to explain her study technique with clarity. With the exception of 2 students, participants were not frustrated by the technical vocabulary required of their biology class and thought the language demands were equal between both biology and world history courses when asked to compare.

Collective narratives about students' previous experiences in their home countries demonstrate that their previous schooling did not train them to have the high level of content expertise expected by their American high school. Their interview data show that the lack of rigor in schoolwork was a shared theme across students from various countries.

> (Student 8) *In Korea, I didn't study*
>
> (Student 7) *Textbook is only for fashion*
>
> (Student 9) *I never studied in Guatemala*
>
> (Student 6) *You don't need to study*
> *Teachers just try to make you pass a test*
>
> (Student 9) *I just study for 20 minutes and maybe for two classes*

Some students expressed that this deficit of rigorous academic expectations was accompanied by commonplace cheating within their previous schools.

> (Student 11) *I could get help from my friend*
> *Like middle of tests I could copy*
> *No seriously, it was easy for us*
>
> (Student 12) *We would put the [multiplication] tables on the desk so that we could cheat*

Such cheating was not only a reflection of student's individual schools but the cultures around which those schools were created. The American school chosen for this study had an honor code that was strictly enforced. This was clearly a cultural shift for some students and it may have affected their study habits by requiring them to develop more self-reliance as a learner, an ideal trait for independent learning methods such as the mobile vocabulary tool.

Although most student participants recalled having some science education in their home countries, 2 students came from educational backgrounds that were specifically tailored for their career paths.

> (Student 12) *We didn't really study science*
> *They didn't teach that type of stuff*
> *They only teach math and how to write*
>
> (Student 2) *In Pakistan, the study of biology, chemistry and physics was not*
> *Important for the engineers, accountants and things like that*
> *We did not spend a lot of time on science for pre-engineering*
> *That was for the ones who wanted to be doctors*
> *Here we spend many hours on studying for something that we don't need*

These responses demonstrate a prioritization of disciplines that did not exist in the comprehensive American high school used for this study. These students found

themselves thrust into a discipline for which they had little understanding, which likely affected their feelings about biology as well as their learning behaviors and study habits.

Several key pieces of students' story of learning emerge from these responses. To begin, questions about school and science background showed how rigorous academic standards that were an accepted part of this school's culture were new experiences for several students. There was also evidence that these ELLs were largely unfamiliar with conducting scientific experiments or hands-on projects because of reliance on textbooks as the main source of information or because they had not studied science before in school. The theme most often used to describe their specific science learning practices was that they were not previously expected to have the level of scientific understanding required in their ELL Biology class. Few students remembered performing scientific experiments, using a laboratory, or handling lab equipment. Furthermore, the need to study seemed to be an unfamiliar requirement based on their previous school experiences. The depth of knowledge required of them in their native country schools appeared to have been less than their American high school biology course, but they did not show evidence that they had adapted their previous study habits to meet these new learning demands.

When I Have My Computer In Front of Me, I Don't Want To Do Anything

The ELL Biology teacher did not use any student-centered technology in her lessons, so any computer use by the student was independent of a specific assignment or requirement. Students were asked if they ever used a computer to study biology or another subject and if so, to describe the circumstances of the computer use. It is

important to note that this question about computer use came before the ELL Biology teacher introduced an internet-based study option to prepare for the state biology test. When students were asked about studying via computer at the end of the data collection period, the responses varied from their original ideas presented below.

Data from pre-interviews showed that all participants favorably viewed computers in general but not all participants responded that they used computers for learning science. Those who had used a computer for science study all referred to the internet as a source for independent study.

> (Student 1) *In our country only the teacher can give us what we have*
> *But here we can do the Google things*
> *We can use the internet here*
>
> (Student 2) *If I don't know the answer, then I use Google*
>
> (Student 4) *Maybe I don't understand the question and I am looking for the question in my notes and notebook and I can't find it so I go to Google*

Students also mentioned the ELL Biology teacher's Blackboard page as a place to find information, but this was seen as less useful than using an internet browser to find information quickly. Only 1 student who mentioned internet usage indicated that searching for answers on the internet did not appeal to him.

> (Student 12) *I have never Googled stuff for Biology*
> *I feel like Google doesn't help for Biology*

This English language learner was asked if he could expand his answer to provide a reason for this belief, but he was unable to vocalize a specific explanation, either due to his limited English or inability to think reflectively on this subject. Two students

specified that they used the internet specifically for language support rather than finding content using a browser.

> (Student 11) *I don't look at the computer much for definitions or studying, except for dictionary*
>
> (Student 7) *I lost my dictionary and I started using Internet*

Four students were adamant that computers were unhelpful for studying because they provided too much of a distraction. They shared the opinion that computers were entertainment devices rather than instruments for learning.

> (Student 7) *I am always multi-tasking like playing and studying at the same time*
>
> (Student 12) *[I don't study with a computer] just chilling, play games*
>
> (Student 9) *When you have a computer, you never want to study*
> *You just want to watch something and*
> *You do other things like check your email or kind of stuff like that*
>
> (Student 5) *When I have my computer in front of me, I don't want to do anything*

I Have Never Used an App for Studying

After students were asked about their computer habits, they were asked to describe their opinions about iPods. As with the previous question about computer use, the following responses were collected before students began using the mobile vocabulary tool. All student participants responded that they were familiar with using an iPod Touch or iPhone before the data collection period began, even if they did not own one. When asked during the pre-interview if they ever used an iPod to study, most participants answered that they had not. Some seemed surprised at the idea of using an entertainment device for schoolwork.

> (Student 11) *I do not have an iPod*

if I did have one, then I probably would [use it for study and play]

(Student 3) *Sometimes I borrow it but not for studying, to listen to music*

(Student 4) *I use it for listening to music and playing video games*

(Student 8) *I have never used an app for studying ever*
Only games

Students were asked why they used their iPods only for music and games rather than study. A few indicated that iPods were too limited for what they wanted to do.

(Student 8) *The laptop is better than iPod to me*
The iPod is hard to type and the time [speed] is too slow

(Student 7) *It is uncomfortable*
It is so small

Participants also reported that their current teachers in several classes, including biology, world history, and mathematics, encouraged them to use Blackboard to assist studying and homework completion, but no teachers discussed using mobile applications for these purposes. Although iPods and iPhones were allowed in school, individual teachers had the option of banning their use during class time. Students were not informed that many functions that made Blackboard helpful, such as reviewing lecture notes, could be performed on iPods. Four participants reported that they tried to use dictionary apps in class, but teachers did not allow the devices to be used at all.

(Student 10) *I use my iPhone as a dictionary*

(Student 4) *[Teachers] always tell us to put it away*
Because they think you can only use it for doing not important stuff

(Student 6) *They don't let us use the iPhone in school or classes*

(Student 5) *They say that you can't even take your iPod out*

The overall message from participants as concerns employment of technology as a study aid was that they heavily favored computers as the best instrument for study. iPods were also popular among all participants. Students had a clear view of both computers and iPods as entertainment sources, but neither technology was universally viewed as a helpful study device. The opinion shared by all was that both computers and iPods were primarily seen as gadgets for videos, games, and music and were limited in their function as study tools. Students had also been encouraged by some teachers to use computers to study but using iPods for the same purpose was discouraged.

Students' Story of Learning

During the pre-interviews, student responses showed minimal emphasis on personal study skills, collaboration, and discovery learning. By fusing these interview data together, a collective story emerges that uses shared experiences across individuals to create a student vignette summarizing common experiences, attitudes, and habits. This section describes those summarized commonalities by describing an average student in the ELL Biology class.

The collective story of learning derived from interview data shows a student who is adjusting to the expectations that he can, and must, become proficient across many academic areas. These expectations vary from those in his native country where he may have had minimal previous instruction in biology. Moreover, the methods for obtaining proficiency differ as well. In the ELL Biology class, he uses teacher-provided notes rather than creating his own notes. He does not employ skills such as concept mapping or annotation when studying outside of class. He has nominal experience with study skills

and relies on basic memorization techniques to learn information. The memories he recalls from his native country schools indicate that study skills were not necessary for him before because the learning demands of school in his native country differed greatly from the demands of high school in the United States.

In addition to basic personal study habits, he also lacks experience with collaborative learning and discovery learning. He reports that opportunities to learn science through structured laboratory work or discovery learning in his native country were very few. He estimates that "maybe ten percent" of class time per month is reserved for laboratory work in the ELL Biology class. Compared with the little time he performed lab work before, this is a significant increase.

He has some previous school experience with biology, but this background can both help and hinder his achievement. The vocabulary used for science does not transfer as easily as the concepts do, and it can be both beneficial and frustrating that he knows the vocabulary in his L1 and L2. Science requires a precise vocabulary and he can become aggravated when translating technical English words that do not have cognates his native language.

In his native country, science textbooks and teacher lectures are the primary modes of knowledge acquisition. These two sources are given great importance because they are not supplemented with online or technology-based resources. He cannot recall using a computer to extend or enhance learning in his native country. This lack of experience with educational technology may have contributed to his limited proficiency using online or mobile resources. He views technology as source for entertainment and

has minimal experience using it for learning. His teachers encourage him to use one resource, the computer, perhaps because they do not view other technologies as helpful or useful. He has not been taught how to use mobile devices such as iPods to assist academic learning.

This student vignette encompassed the major themes from student interviews conducted before students began using the mobile vocabulary tool. These themes created a picture of a student who made an effort to meet academic standards in biology and discover best practices for their own learning styles. Although ELLs primary struggle may be with overcoming language barriers when learning content (Carrier, 2005; Lemke, 1990), these data illustrate that previous educational experiences and personal study habits also influenced students' academic achievement.

Conclusions From Student Post-Interview Data

The focus of the post-interview questions was participants' perception of their experience using the mobile vocabulary tool over the 8 week data collection period. Information from post-interviews was meant to answer this study's first research question:

> RQ 1: How did these ELL Biology students perceive the iPod-based vocabulary tool as a means of informal study?

Student participants were given 2 multiple choice vocabulary tests focusing on biology-specific terms at the beginning and end of the data collection period. They were also given weekly questionnaires that provided data on how frequently each student used the mobile vocabulary tool. Students were supposed to use the tool an independent study aid

outside classroom hours where their rate of usage could not be monitored, so data from weekly questionnaires was used to illustrate average frequency of independent use while the vocabulary tests offered a way to measure student vocabulary improvement from the beginning to the end of the data collection period. These 2 data sources allowed me to tailor questions to each student such as "I see that you used the tool often for the first three weeks, but then only used it a few times after that. Can you explain why?" Such questions gave me the capability to go beyond the standard questions to elicit deeper feelings about students' perception of the mobile vocabulary tool.

As with the pre-interviews, several themes emerged from post-interview data across multiple participant responses. Students discussed their perceptions of the tool's utility as a study aid and how they used the mobile vocabulary tool as one of their biology review options. Five participants did not own an iPod, but borrowed one from a friend to use occasionally. All 11 post-interview participants reported that they had used the tool 3 times or more and all were able to provide some insight into their feelings about using the mobile vocabulary tool to assist their learning.

You Can Concentrate on Just One Special Thing

Students were asked to rank their four biology review methods from most to least helpful. A majority of students responded that the after school review sessions and online quizzes were more helpful than using the mobile vocabulary tool or studying independently with notes and the textbook. Participants were asked to explain why they felt this way. Some students described that the doing online quizzes on a computer

required them to narrow their focus on biology rather than multitasking between programs.

(Student 4) *You have to be more concentrating on the computer*

(Student 3) *[With computers] you can concentrate on just one special thing*

(Student 7) *The online quizzes were more helpful because they asked the harder stuff*

(Student 8) *You had to think more*

These responses show a different attitude from pre-interview data where students had described computers as mostly unhelpful study aids, apart from online dictionaries or Google searches to find biology information. Having been given an opportunity for challenging online study, most students embraced this resource and there was no discussion of computers as entertainment, as there was before. Although it is doubtful that students no longer considered computers as entertainment devices, the online quizzes seemed to give them a different way of measuring the value of computers as study aids.

When asked to compare computer multitasking with iPod multitasking, students pointed out that it was harder to keep a single-minded focus while studying with an iPod. They reported that it was difficult to concentrate when there were so many options for entertainment available to them. They saw their iPod as a private device and, unlike computers, were not as willing to combine their work and play together with this particular technology.

(Student 11) *Its kinda hard to study on the iPhone cause you might want to look at Something in the internet and forget what you're going to do*
You go on and go on and you find out its ten or nine and you have to sleep

(Student 5) *When I take out my iPod I play games*

[iPods are] for myself, my things, my personal things, Facebook, pictures, notes, internet, music

(Student 10) *The iPod is only for my songs and my games*
Don't go putting other things like [the vocabulary tool] on there

These comparative observations illustrate that some participants saw a clear demarcation between two devices that are largely interchangeable in function. iPods and computers can run the same types of programs, but the perceptions about them differ greatly due to the more personal nature of the iPod and its ability to serve as means of self-expression.

With the iPod, You Have It There

An area where computer utility diverges from mobile devices is in portability. Computers, even laptops, deviate significantly with iPods in size, weight, and start up time. Asking students to recall where and when they had used the mobile vocabulary tool was a key question in understanding their perception of the tool's mode of delivery. The mobile iPod platform allowed them access to the vocabulary tool throughout the day for quick periods of time in a wide range of places. These when-and-where responses detail participant perceptions of an iPod's value for 'anytime' learning. The number of places they detailed demonstrates their perception of the tool as both portable and easily accessible, with no internet connection required.

(Student 2) *The bus stop*
In the bathroom
When you go to bed and you can't sleep
When you don't feel sleepy at night

(Student 1) *In the cafeteria*
Sometimes in [English] class

(Student 11) *I borrowed [an iPod] in class*
I used it at school

(Student 7) *Usually at home*

(Student 8) *In the morning and at lunch*

(Student 6) *Afternoon, when I get tired*

Students were asked why they chose to study in so many places, especially places where studying might be cumbersome, such as the cafeteria or bus stop. Students verbalized that the iPod's portability made it easy to fit into their established routines.

(Student 9) *I just started listening to my music*
Then I played a game
Then switched over to playing the [vocabulary] game
Then I get excited about the questions and started playing

(Student 10) *Every class we ended with five minutes left and I always listened to my music*
So I just started to play the [vocabulary] game

(Student 10) *With the iPod you have it there*

Students felt the mobile vocabulary tool synchronized easily with their iPod habits as opposed to computers. Their responses demonstrated that they perceived the vocabulary tool as unobtrusive and easy to use. Although some students were not enthusiastic about learning via their iPod, as shown in the previous theme, the majority exhibited through their actions that they had an affirmative perception of the vocabulary tool's mobility.

Every Time You Learn Something New

Students were asked to describe their overall perceptions about the vocabulary tool in both the post-interviews and the weekly questionnaires. Responses from both sources were analyzed together to extract three distinct categories of impressions: negative, positive, and mixed. Because studying via iPod was a new experience for

nearly all participants, these impressions represent emergent attitudes about students' perceptions of mobile learning. Data from both questionnaires and interviews are included in the information below.

Negative impressions. Negative perceptions about the mobile vocabulary tool seemed to revolve around the tool's mechanics and subject. Some students reported that it did not always run smoothly on their iPods and it was frustrating when the program ran slowly or crashed mid-play. Negative adjectives used describe the tool included "boring" and "unuseful." One participant pointed out that, no matter the format, she did not like the tool's science-focused subject.

(Student 5) *I don't like biology and I don't like the biology [vocabulary] game*

Other responses noted that the tool's gaming format made the response time per question too brief to be a helpful study aid.

(Student 7) *Time limit is too short*

(Student 8) *I need more time to think*

(Student 4) *You don't have enough time to go look in the book because there's a time limit*

Despite these problems, the 5 students who voiced complaints still chose to use the mobile vocabulary tool a minimum of three times as a review option to prepare for the state standardized exam. One participant pointed out that, even though he had problems with the tool, those problems did not inhibit him from using the tool as a study aid.

(Student 9) *I didn't understand many of the questions*
Because the questions were really kind of weird
I couldn't understand all of it
I always got wrong those questions
But I never stopped doing it

I kept on trying

Mixed impressions. It is important to note that 3 of these participants who expressed negative impressions—Students 4, 5, and 8—had only unenthusiastic things to say about the tool. Students 7 and 9 voiced both positive and negative perceptions, indicating that they had multiple perspectives on the tool's utility as a study aid.

These 2 participants, along with Student 11, had mixed impressions about their experiences using the mobile vocabulary tool. One student described the tool as "annoying, but useful." When asked to explain his contradictory opinion, he reported that he hated studying and nothing could change that. Another student who had mixed feelings reported having a similar attitude about studying.

(Student 7) *I feel like different ways*
This way I feel "this is awesome," and this other way, "I hate this"

(Student 11) *It is kind of hard but it's good to study and it's kind of boring too*

Weekly questionnaires showed that both these three students used the mobile vocabulary tool several times each week. This demonstrated that they acknowledged the tool's utility as a study aid, despite their professed feelings about schoolwork.

Positive impressions. Five student participants reported only positive impressions of the vocabulary tool. In each post-interview, students were asked to choose words to describe their feelings about the mobile vocabulary tool. Some adjectives were negative, but the majority of students gave positive words to express their perceptions. Affirmative words used by participants included "awesome, brilliant, good, fun, nice, cool, easy to use, easy to remember, helpful, interesting, and comfortable." Some students felt that the tool provided entertainment and made learning easier.

(Student 1) *Every time you learn something new*

(Student 2) *It's easy to learn fast*

(Student 7) *Make me memorize some words*

(Student 1) *It is fun like that*

(Student 9) *The more you play the more you learn*

The mobile vocabulary tool contained 250 questions that students encountered repetitively if they used it frequently. Participants reported that this repetition was useful and contributed to their positive impressions.

(Student 10) *It helped me a lot studying*
It repeated and repeated the old questions over and over again
You can get it into your brain
I don't know but I think it is a way to study
You don't have to worry about all this that much
I think it was kind of easy

(Student 6) *The good thing about it is that it shows you the question again and again*
It helps you to remember that

(Student 3) *It makes you think harder than usual*

One student revealed he did not view the tool as a means of studying at all. He did not like to study, but he did enjoy using the vocabulary tool, suggesting that he did not see it as a means of learning.

(Student 10) *I thought it was pretty good*
I wasn't studying for biology or anything like that
But when I was free, I was playing the game, I was using the app

Other participants did not share this student's viewpoint of enjoying the game while ignoring its educational aspects. All other students reported that they viewed the tool as a

study aid used deliberately to review biology vocabulary words as part of their test preparation.

Summary of Student Perceptions

The perceptions provided by students during post-interviews and questionnaires contribute to the ELL story of learning by combining their educational background and technology usage with a learning tool that focuses on vocabulary development. Data illustrate that ELLs had a range of impressions about using the mobile vocabulary tool as a means of informal study, with the majority of opinions favoring it as a helpful addition to their collection of study methods. Most students did not favor the tool more than after school review sessions or online quizzes, but their responses showed that the tool did provide them with assistance in unique ways, including being able to study in atypical places and times. Problems with mechanics and negative feelings about academic work contributed to negative impressions of the tool.

Findings from Teacher Interview Data

The ELL Biology teacher at this school had given presentations at both county and state-level workshops about working with ELLs to master science content. She had already reflected on her best practices and was able to converse about them easily during her interviews. It was clear from her responses that she had specific methods for teaching English language learners that did not correspond with more traditional vocabulary-focused techniques used in many science courses with ELLs (Carrier, 2005; Rutherford, 1990).

High Expectations

As with the student interviews, the pre-interview for the ELL Biology teacher sought to understand how she viewed her students' learning and cultivated it within the framework of biology content. The high expectations she set for her ELL students aligned with research advocating a focus on constructing meaning rather than memorizing vocabulary (Duran, Dugan & Weffer, 1998; Miller, 2009; Rutherford, 1990). In addition to teaching the ELL Biology class, this teacher also taught AP Biology which, according to her, gave her insight into how high expectations can help students succeed academically.

> *My first couple of years, I didn't [have the same expectations for ELLs and general education students]*
> *I watered down the ESOLs a little bit, I removed some things out*
> *I realized that I had kids in the [ESOL] class who were highly functional*
> *So now I give everybody the same push*
> *No matter what their intellectual ability or language ability*
> *All are expected to perform well*
> *[ELLs] are not treated specially*
> *That is one the messages that I try to get to them*
> *High expectations for the students in the class*

The ELL Biology teacher observed that maintaining expectations for all students regardless of linguistic or educational background was not a uniform practice across her school district. She became frustrated during the interview when describing ELL Biology teachers in other schools who were not meeting science curriculum standards in their instruction of English language learners.

> *We have a colleague from here that moved to a different school*
> *I get all of these emails*
> *"You cannot believe that they are not teaching this"*
> *"They think it is not important"*
> *I get reports of whole chunks that are not being taught*

The Skills They Need to Move On

Although she set high expectations for students in her ELL Biology class, this teacher understood that they did not have the same skills as general education students and some skills needed to be explicitly taught and scaffolded. She organized her classroom practices to adapt to the unique needs of language learners. Lecture notes were her principal means of scaffolding student studying.

> *I give them the [lecture] notes*
> *I know for some of them taking notes is a very slow process*
> *I don't want them to waste time on the copying*
> *I want them to focus on understanding the explanation*
> *I want them to pay attention and to follow the process*
> *Not to be hung up on copying word by word*
> *They do not understand what they are writing*

She recognized that ELLs in her biology class would have to complete at least two more science courses to meet graduation requirements. She communicated with her colleagues teaching those courses and knew that, in addition to biology content, she also had to prepare ELLs for success in classes that were not as heavily scaffolded as hers.

To get them familiar with using Blackboard for online help, a practice used by upper-level science classes, she posted information on Blackboard regularly and promoted it as a resource that students could use to complete assignments. She showed them ways to study, but made sure to integrate these into daily lessons so they heard the information repeatedly.

> *There is no one way to study*
> *If I see that they are having problems and they want to know how to study I'll work with them*
> *I need to make sure that they have the skills needed to move onto the next class*

She also taught the ELLs how to skim a science text and note text structures such as headings and captions.

> *The textbook has a lot of words and they are very scared of it*
> *I ask them to look at all the pictures and read all the captions*
> *For a lot of [ELLs], due to the language issues, pictures are better than words*
> *So I said 'look at the picture, analyze the picture, look at the graph*
> *Just try to follow the process*
> *If you [can follow the process] then you know it*
> *But if you look at the drawing and you don't understand what is going on*
> *Then it means that you don't know it*

She stressed that reliance on the textbook as an information source was not effective for her ELL students. The text was often confusing for them, so she used other means to support their understanding, often using oral explanations and images that were more accessible than print-dense texts.

> *[ELLs] have the issues with not being able to read fast enough*
> *It is hard for them to decide what is part of the unit and what isn't*
> *They get all bogged down*
>
> *I tell them it is not a matter of just reading it*
> *Because you read and you read and you read and it doesn't mean anything*
> *I tell them that, with a blank piece of paper, try doing a series of sketches explaining the whole process that we just learned*
> *Simple drawings with a lot of stick figures*
> *Try to explain to somebody or, if this is a problem with the language, then explain to yourself how something happens*
> *If you can explain it then you know it*

Explain the Concepts

The ELL Biology teacher frequently used the word "explain" throughout the interview. It was the basis of her teaching philosophy for all students.

> *With biology is you have to explain the concepts, even for English native speakers*
> *Science is one of the areas where it is really hard to learn on your own*
> *You usually need somebody to explain the concept and give you an analogy or develop the idea*

She was asked to expand upon that philosophy and give an example of how she explains a concept. She detailed a three-step process that first introduced a 'science story' with a plot and characters. This story would be delivered orally with basic images as pictures. She did not employ professionally made videos and rarely used professionally made images in this initial step. This was done purposefully to limit academic language and check frequently for understanding.

> *For example, how the information in DNA is transformed into a protein*
> *You can read it in a textbook and you are never going to get it or understand it*
> *You have to make the drawings*
> *You have to explain 'and this goes here and this moves out of the nucleus'*
> *You have to physically kind of do an animation of the process*
> *If you just look at still pictures, it is really hard to put it together*
> *So you have to kind of tell a story*
> *Make it all into a story*
> *Kids like stories with a beginning, middle and end*

The next step of the explanation process involved replacing the character names within the science story with their proper technical names. This stage might include additional pictures and images to supplement the basic drawings. Once these terms were assigned to a character, the third step entailed retelling the story a final time with all the "heavy-duty jargon" intact. A short video might be used after this step or posted on Blackboard as additional help.

> *That is what I try to do with these complicated concepts*
> *Go through the whole process and make it very fluid*
> *Try to eliminate as much of the heavy-duty jargon and make it in simple terms*
> *Once they can follow the story in simple terms, then you go back and say 'oh remember this, by the way that has a special name', and we add the little special names*
> *So first they get the story then we add the special names to the characters*
> *Then we go through the whole process again and there you have it*
> *If I just give you the dry points of how the whole process works, it is very difficult*

because it is all very heavy-duty terminology

Use the Terminology In Context

From the example, it is clear that the ELL Biology teacher focused on teaching biological processes rather than vocabulary. She found it effective to fold vocabulary into the context of her lessons and encouraged students to think about how science words related to concepts. She felt that associations rather than definitions were a more thorough measure of comprehension.

> *We use the terminology in context*
> *Even a lot of the [native English speaking] kids do not understand and cannot tell me, for example, tell me what 'sleep' is*
> *They have a hard time explaining to you what the word 'sleep' means*
> *But they can use it in a sentence, they know what 'sleep' means*
> *It's the same here, they may not be able to give you a definition of the word but they know where that word belongs*
> *They know the actions associated with that word*

The ELL Biology teacher's style was to create an idea of a concept and then assign a name to it. She did not introduce any word in her lessons before there was a concept for students to associate with it. In addition to introducing vocabulary in this manner, she followed this method for testing as well.

> *There are no vocabulary questions [on my tests]*
> *Everything is integrated*
> *There are no specific questions about specific words*
> *The questions have the [academic science] words on them whether it is multiple choice or in the free response*
> *They have to use the word in the response*

She felt this method of integrating terminology helped students become better prepared for the types of questions they would see on standardized biology exams and it maintained a level of academic rigor that students would encounter in other science

classes after finishing biology. Getting them used to this method was time-consuming, so she felt it was important to set the standard from the very beginning of the course.

> *At the beginning of the year, during tests I circulate a lot, I help them*
> *The questions are long and very complicated*
> *So I usually rephrase the questions for the ones that have problems*
> *Not simply find them [in the glossary], just rephrase them*
> *At the beginning the first quarter or so there is a lot of rephrasing for questions*
> *I forbid them from using the glossary*
> *Because the glossary is strictly a memorization list that doesn't make absolutely any sense to them*

The Teacher's Story of Teaching

Data from the ELL teacher's pre-interview made it apparent that her high expectations and teaching style affected her students' learning. She introduced vocabulary as part of biological processes rather than focusing on definitions and students were never tested on definitions that were divorced from concepts. This practice clarified why student participants responded that they did not feel that biology vocabulary was more difficult than content vocabulary in world history. Her techniques ensured that vocabulary words were introduced and used in context of a larger concept, eliminating the possibility that definitions might be too abstract to understand.

She recognized that ELLs needed scaffolding to reach the rigorous standards she maintained. This scaffolding was integrated into lessons in the form of structured notes, tutorials on textbook use, use of Blackboard as an independent study resource, and science stories with plots and characters that were designated with technical names. Even though she provided these specialized supports for her ELLs, she maintained that expectations for English language learners should never be less than those for general education students.

The ELL Biology teacher also had certain opinions of technology use in the classroom. She did not rely too heavily on technology and integrated it sparingly into lessons and homework assignments. During interviews she expressed that she was energized about anything that helped her ELLs learn, including the mobile vocabulary tool. Although she was happy that her students had another study aid at their disposal, she admitted that she was not familiar with using mobile technologies for learning purposes.

> *I am pretty weak in that everything that you can do [with mobile technology] because I have a wimpy cellphone*
> *I don't have a smartphone*

There were two technology outlets that she used frequently. First, she encouraged her ELL students to use Blackboard to access homework help and posted weekly quizzes there to get ELLs comfortable with this resource that was unfamiliar to them. Her second technology aid was an Interwrite Pad. This interactive tablet allowed her to circulate around the classroom while lecturing by giving her a way to 'write' on the board without being near it. She recognized that there were other tech tools she could use to assist her instruction but she would not incorporate them unless she saw a direct benefit to her students' achievement.

Teacher Post-Interview Findings

To prepare her students for the state standardized exam, the ELL Biology teacher promoted four review options, emphasizing the after school reviews and the online quizzes. In informal conversations with me during the month leading up to the exam, she stated that she preferred these two methods because she could monitor their progress

herself, either in person during review sessions or using the online quiz tracking system. This indicated that her perception of the mobile vocabulary tool was less helpful to her as a teacher. She favored after school reviews and online quizzes for the feedback she received from them, whereas the mobile vocabulary tool did not give her any information about student progress. In her post-interview, she was asked if she encouraged her ELLs to use the mobile vocabulary tool.

> *Definitely!*
> *They are all technology savvy, they love to play with their gadgets, anything helps*
> *If they do 15 minutes in their iPod and then half an hour with their notes, that will be great*

This response illustrates the ELL Biology teachers' mixed impressions of the mobile vocabulary tool. She recognized that it could be helpful for her students and they would likely use it because it fit into their established habits. However she preferred the tools that gave her information about students' learning and the mobile vocabulary tool had no way of doing this. She encouraged students to use it, but showed greater enthusiasm about review sessions and online quizzes.

The teacher's tone when discussing her students' performance on the state biology test was one of exasperation. Several students had not passed the test and the ELL Biology teacher was unsatisfied with this result. When asked to speculate about the cause behind the failures, she attributed it to students' behaviors and attitudes.

> *A significant number of unmotivated kids just fed on each other in a circle of unmotivation*
> *A significant number of kids with attendance issues*
> *If they aren't in class there's nothing we can do about that*
> *If they kept on working on it, they would have done well*
> *The weeks I was able to catch them in the hall after school and stay, they did just fine*

But since they didn't come generally, we couldn't do anything

The ELL Biology teacher was asked if she planned to change her instructional techniques in response to the low motivation and poor independent study habits exhibited by several of her ELL students.

I don't think I'm going to change anything cause it worked for these kids
After this they have to take mainstream classes, so they need to be prepared
I cannot cut material out or do something different to support them more in class

She expressed that students who did not pass the exam had not lived up to their potential and her interventions to help them during the previous two months were ineffective due to issues outside of her control.

Her belief in her current methods of teaching was strong. She had refined those techniques over a number of years and did not feel that her system for delivering content needed refinement. She pointed out that, in addition to attendance issues, students struggled with independent learning.

The other interesting thing I noticed was study time
I asked them how long they studied for the test
Most of them studied for less than an hour
Some of them, 20 minutes
A lot of them said "nothing"
I don't know how to instill in them that they need to study

She acknowledged that perhaps the mobile vocabulary study tool was one way to get them to interact with the biology content more. Despite her focus on low motivation as the cause of failures in the ELL Biology class and her statement that she would not change her teaching habits, she appeared to be thinking of ways to alter the ELL Biology course to reach her unmotivated students. Immediately after the interview, she asked if the tool was available on other platforms. She appeared disappointed that it was limited

to iPod Touches and iPhones and wondered aloud if she could find a way to get devices for students who did not own them.

Her final inquiry about getting iPod Touches for all students revealed a perception that the mobile vocabulary tool might become a bigger part of her teaching methods in the future. This study did not introduce the tool until the final quarter of the school year. The ELL Biology teacher stated in her pre-interview that she introduced study skills in the first quarter and reinforced them throughout the year. It is possible that she was considering integrating the vocabulary study tool as a study resource more in the future. When asked if she was contemplating doing such a thing, her reply was "maybe."

Summary of Teacher Perceptions

My second research question for this study asked how the ELL Biology teacher perceived the effect of the vocabulary tool on her students' learning behaviors. Students who used the mobile vocabulary tool as a study aid did so outside of class time. The ELL Biology teacher could not accurately observe or monitor how often it was used by her ELLs. Despite this limitation, she had perceptions about the tool that are discernible from her post-interview and informal conversation data.

Based on her statements and behaviors, it can be concluded that the ELL Biology teacher had mixed perceptions about the tool's potential effect on study habits. On the positive side, she recognized the impact that the mobile vocabulary tool could have on her students by giving them a way to study that blended into their lifestyle more easily than formal study. On the negative side, she did not heavily promote the tool as a resource because she recognized its shortcoming for her needs as an educator. She

expected her ELLs to use the study skills she taught them in class and the vocabulary tool did not fall into that arrangement. Furthermore she knew that she needed a way to increase student opportunities for interacting with biology content, especially for students who did not study at all. Therefore, although her perceptions of the tool's effect during this study were limited due to her decision to promote online quizzes and after school review sessions, those perceptions could change if she made the mobile vocabulary tool into a larger component of her instruction in the future, an option she seemed interested in pursuing.

Summary

In this chapter, I presented data about the learning background, habits, and expectations of both student and teacher participants. These data were used to better understand the perceptions of participants after eight weeks of using the mobile vocabulary tool to review for the state standardized biology exam. Student participants reported both negative and mixed impressions of the tool, but the majority of students had positive perceptions of their experiences using the tool for informal study. The teacher participant had mixed impressions of the tool. Information from her interviews suggested this may have been because she had strong feelings about the effectiveness of her established teaching methods. However, she seemed to understand the impact that the tool might have on unmotivated students, demonstrating that her perception of the tool remained flexible.

5. DISCUSSION

The purpose of this study was to discover user perceptions of a mobile tool for learning biology vocabulary within a small group comprised of intermediate-proficiency English language learners and their biology teacher. It supports existing research clarifying the benefits of teaching academic language in context (Carrier, 2005; Jaipal, 2001) as well as recent research into the increasing body of literature on mobile learning (Traxler, 2009). Data contained within this research are intended to provide authentic, first person accounts taken from a real-world educational setting.

Thirteen students from 10 different countries initially participated in the study, with 11 remaining by the end of the data collection period. These 13 students represented 7 different language backgrounds, including Chinese, Korean, Nepalese, Spanish, Turkish, Urdu, and Uyghur/Japanese. All students who participated were classified as intermediate ELLs by the WIDA assessment administered by the state board of education. One teacher, a native Spanish speaker, also participated in this study.

The vocabulary tool was available for free download to any iPod Touch or iPhone. Of the 13 student participants, 8 owned an iPod/iPhone and 5 did not. Students without a device were encouraged to borrow one from a friend from time to time to use the vocabulary tool. Students were encouraged, but not required, to use this vocabulary

tool as a review mechanism for preparing for the state biology proficiency test required at the end of the school year.

The mobile tool contained a database of approximately 250 multiple-choice questions that focused on vocabulary words specific to biology content. Formatted to mimic a trivia game, each round consisted of ten questions pulled at random from the 250-question database. Students were shown each question along with 4 answer choices and had 15 seconds to choose an answer. If a student chose incorrectly, the correct answer was indicated before the next question appeared. Points were given for answering both correctly and quickly.

Summary of Research Procedures

Students used the mobile vocabulary tool independently for 8 weeks leading up to the state standardized biology test. The tool was 1 of 4 study options available to them, along with after school review sessions with the teacher, online quizzes posted on Blackboard, and independent studying. Students were initially interviewed before the 8 week period to collect narrative information on several points of interest including educational background and study habits. Interviews after the 8 week period focused on the ELLs' perceptions of their experiences using the tool as an informal study aid outside of a classroom setting.

The teacher in charge of the ELL-only biology class was also interviewed before and after the 8 week period. Her interviews focused on her practices for teaching science content to ELLs and her perceptions of study habits and educational technology use.

Discussion of Findings

Student Perceptions

It is worth noting as I begin a discussion of the findings related to students' perceptions of the mobile tool that since all participants were English language learners, it is a possibility that they did not have the English proficiency necessary to voice their opinions and recollections precisely. Some important thoughts may have been overlooked because participants did not have sufficient words to describe them.

What appears certain is that issues with English language competence, as evidenced in the student participants' comments, contributed to difficulty merging their previous biology education with their present coursework. Although some students found it easy to connect scientific words between English and their native language, others saw biology vocabulary as a language completely separate from either their L1 or L2. Despite this difficulty, some students thought that world history vocabulary was more complicated than biology vocabulary due to its imprecise or indistinguishable definitions.

They shared personal information about school memories from their native countries. Overlooked cheating and cursory content knowledge were two factors that separated past experiences with their present American high school. Few recalled being required to learn information as deeply in their country as their ELL biology teacher expected here. Students also reported that they were currently using rudimentary study habits to memorize information, including staring at their notes to capture a visual image.

Computers and iPods were both seen as devices for entertainment and play, but computers were also perceived as educational tools that could be used to assist coursework. Before using the mobile vocabulary tool, few students had attempted to utilize iPods as study devices and those who did used them as electronic dictionaries. Teachers encouraged students to use computers to assist learning, but students reported that iPods were not allowed to be used in class at all. All student participants were surprised to discover that their iPods could be used for educational means.

After using the mobile vocabulary tool for 8 weeks, student participants reported a range of overall perceptions about their experiences using the mobile vocabulary tool to study outside of class time. These perceptions answer this study's first research question:

RQ 1: How did these ELL Biology students perceive the iPod-based vocabulary tool as a means of informal study?

Based on student responses, perceptions of the tool's utility as a study aid were both explicit and implicit. Implicit perceptions were opinions that were not stated directly, but could be extracted from information regarding how, why, and when students chose to use the tool to review biology vocabulary. Explicit perceptions were characterized by direct answers in which students voiced positive and negative opinions.

Implicit student perceptions. Mobile learning has gained popularity as a means of 'anywhere, anytime' learning (Kukulska-Hulme, 2009; Traxler, 2009). Mobile learning's ability to divide content into small chunks of learning was evident in students' responses about where they used the mobile vocabulary tool. Students reported using the tool in places where studying is normally difficult to accomplish, such as a loud cafeteria,

a bus stop, or five free minutes at the end of class. Pulling out a book or computer in these places would be awkward, but the iPod's small size made it easy for students to focus on academic work in non-academic spaces. Although no student explicitly said that the iPod made it easy to study small chunks of vocabulary in various places, evidence of this perception was inherent in students' behaviors.

Students also implicitly showed their positive perception of the mobile vocabulary tool when they described how it assimilated easily with their normal iPod habits. Multitasking between music, games, social media, etc. is normal behavior for iPod users and students reported fitting the vocabulary tool into these multitasking habits. One student did not even see the tool as a means of studying; to him, it was just another game. This integration of the tool into existing behaviors demonstrates a positive aspect of the tool's utility as a study aid. Students did not have to set aside time to study, but showed that they could incorporate the vocabulary review into their leisure time without difficulty.

Explicit student perceptions. Students began the study with the opinion that iPods were entertainment devices meant for relaxation and personal use. When students saw that a program on their iPod could also be used for studying, many responded in a positive manner. This finding echoes previous research with iPods (Patten & Craig, 2007; Wei 2008) that showed student enthusiasm for schoolwork increased with the addition of mobile technology. However, many students still favored computers over iPods as academic tools. This perception may have come from teachers encouraging

students to use computers rather than iPods during class time, even though both devices could accomplish the same tasks.

Not all students enjoyed the addition of a vocabulary review game on their iPod. Three students did not have any positive opinions of the tool at all. They explicitly stated that they either did not like biology or they did not like the game format used by the tool. For these students, the mobile vocabulary tool was an ineffectual option for biology vocabulary review.

Other students had complaints about the tool, but still chose to use it because they viewed it as better than studying on their own. These behaviors showed that students preferred a structured review format, perhaps because they did not have the study skills necessary to successfully review material by themselves, an idea supported by data gathered during their before-interviews. Their preference for using a multiple-choice review format over more traditional independent studying also echoes the findings by previous researchers (Grabe & Seigler, 2002; Johnson, 2007) regarding student study habits.

A majority of students embraced the mobile vocabulary tool as a helpful study option. It was not as popular as two other review methods (online quizzes and after school sessions with the ELL Biology teacher) but students still viewed it in a positive manner. Words explicitly used to describe their opinions of the tool included "awesome, brilliant, good, fun, nice, cool, easy to use, easy to remember, helpful, interesting, comfortable." These words are at the core of this study's first research question.

Students principally perceived the tool as an easy to use, interesting, and fun way to informally review biology vocabulary.

Teacher Perceptions

The ELL Biology teacher reported having high expectations for all of her students, including the English language learners. To prepare them for future science coursework, she scaffolded her lessons to teach notetaking, textbook analysis, and retelling skills. She taught biology concepts by creating stories and assigning technical vocabulary to the story's plot and characters. She felt by integrating difficult words into a concept this made the relationships between terms less abstract, a technique also used by the teacher in Duran, Dugan and Weffer's (1998) study.

The ELL Biology teacher had adapted some educational technologies into her class. However, she admitted knowing little about mobile communication devices or mobile learning. She recognized iPods as a potential way to capture student interest in learning, but encouraged her students to use other forms of study that allowed her to monitor student progress. This study's second research question focused on her opinions as a teacher and observer of student performance.

RQ 2: How did this ELL Biology teacher perceive the effect that the vocabulary tool had on her students' learning behaviors?

Based on evidence from teacher interviews, the ELL Biology teacher had mixed opinions about the tool's effect on learning behaviors. She encouraged her students to use computers or engage in face-to-face learning so she could better gauge their understanding. She knew the tool was a valid study option because she wrote the

questions that the tool used to review vocabulary. However, she did not feel as comfortable encouraging use of the tool because it was too independent for her to rely on for proficiency data. Therefore she did not promote it as a study option as strongly as she could have.

Despite this fact, there is evidence to support the teacher's perception that learning via iPod could have potential for her students. She observed that iPods were valuable commodities to students and that they enjoyed interacting with them. She recognized that her students needed more opportunities for independent study and appeared to be considering heavier use of the mobile vocabulary tool in the future despite its inability to provide feedback about student progress. She indicated that she might rely more heavily on the tool the following year, but this study's limited time frame prevented following up with the ELL Biology teacher before the end of the following school year.

Implications of Findings

Literature supporting this study was drawn from three distinct research areas: study habits, mobile learning, and academic vocabulary instruction. Conclusions about the findings can be used to address each of these areas of study, as student and teacher perceptions affect all three areas.

Implications for Study Habits

Underdeveloped study skills and negative study attitudes had an effect on student and teacher perceptions of the mobile vocabulary tool. The ELL Biology teacher taught several formal study skills, but she did not address informal skills such as time management and self-regulation. In her final interview, she indicated that she was both

surprised to learn that many students did not study independently and frustrated that she did not know how to change their habits. Although she taught students how to understand the textbook's text structures, explain concepts both verbally and in pictures, and use Blackboard, her students' performances indicated that these skills may not have been properly absorbed or employed.

Based on interview data from students, few participants showed evidence of having self-regulated study skills. They displayed inadequate time management, with some studying only a few minutes or not at all in preparation for assessments. They reported multitasking during independent study time, shifting between biology, gaming, and social networking, revealing a lack of understanding about the nature of effective studying (Ozsoy, Memis & Temur, 2009).

Lack of sufficient experience with studying outside of a classroom setting may be one reason for participants' unsophisticated independent learning habits. Many students reported that rote memorization was their primary study habit both before coming to this American high school and after they had arrived. Another reason may be that some students did not have the study attitude required to be successful in a challenging content class such as biology. Study attitude is defined as the acceptance of the overall goals of education and an affirmative viewpoint regarding the act of studying (Crede & Kuncel, 2008). Negative study skills were displayed in both before and after interviews. Some students had an aversion to the discipline of biology or did not see how biology fit into their broader education goals, two attitudes that minimized their interest in actively

learning biology information. Others disliked studying in general and reported that they did not study at all.

Despite students' lack of study skills or willingness to invest time in studying, perceptions of the mobile vocabulary tool were mostly positive, showing that the tool had a useful impact on participant study habits. If impressions of the mobile vocabulary tool had been mostly negative, it would show that students did not recognize the utility of the tool as a study aid. But even students who reported mixed and negative perceptions of the tool used it throughout the 8 week data collection period, demonstrating the influence that the tool had on participants' study routines.

Implications for Mobile Learning

Student participants reported that teachers in many classes rarely allowed iPods to be used during class time, although such devices were not banned schoolwide. Informal conversations with the ELL Biology teacher revealed that she required all iPods to be put away during her classes. This no-iPod rule exposed the teacher's impression of iPods as entertainment devices that distract from learning rather than tools that can be used to supplement instruction. Based on data gathered from students during interviews and informal discussions about their instructors' classroom rules, she was not alone in her opinion. Teachers at the site school were unfamiliar with the iPod's educational capabilities. They were not offered professional development opportunities to expose them to mobile learning, but the school did place an emphasis on using computers for research, arts, and presentation purposes. If teachers did not own an iPod or smartphone,

as was the case with the ELL Biology teacher, they might have had little conception of the educational potential of these devices.

In contrast, all student participants were familiar with iPods before the study began. They already had predetermined ideas of the iPod's purpose and utility in their lives. Introducing the mobile vocabulary tool into those established ideas resulted in new perceptions of the iPod's role within participants' identities as learners.

iPods and iPhones offer a way for students to express their personalities and interests by the music, games, etc. that they choose to load onto their device. Perrault and Crummett (2009) made the case that, by giving users a way of conveying their individuality, iPods are like books. Books offer a form of self-expression, a way to illustrate a person's personality. Carrying and displaying books gives individuals an appearance of seriousness and intelligence about the book's subject. iPods offer a similar means of self-expression by allowing individuals to carry and display their seriousness about music, games, social networking, and so on. Few of the student participants had considered iPods as educational devices before this study began. After interview data show that this study had both positive and negative impacts on impressions of iPods as mobile learning devices.

Student responses showed that participants recognized the vocabulary tool's unique ability to provide study material at untraditional times and places. They recalled using the tool at times that would normally be reserved for relaxing, such as directly after class or during lunchtime. Even students who did not like studying and reported mixed perceptions of the tool used it multiple times. That so many students chose to utilize the

tool showed their overall impressions were not limited to the tool's role as a study aid; it was also a means of recreation. The trivia-game format appealed to students and many reported trying to beat their high scores. Many students enjoyed using the tool because it felt more like play and less like traditional studying.

Not all students enjoyed this mixture. One student cited a clear aversion to all biology topics and begrudged the encroachment of such topics onto her iPod. A few students similarly disliked the tool because they felt their iPods were a reflection of their personality. They, like their teachers, clearly delineated between 'technology for work' and 'technology for play' and iPods were contained within the play category. Their interview responses showed that these students disapproved the trespass of an educational tool into their private space. Perhaps because of this, they did not have positive impressions of the tool.

Implications for Academic Vocabulary Instruction

This tool was designed to help students master challenging academic vocabulary by offering them an informal way to interact with content words from biology. Due to the qualitative nature of this study, the tool's direct impact on vocabulary proficiency was not measured statistically, but such data might be collected if the research were replicated and expanded to include a larger student sample.

Student participants revealed that they did not view scientific terms as more difficult than words found in other disciplines such as world history. This was an unexpected discovery, given the challenging nature of scientific terminology (Duran, Dugan & Weffer, 1998; Jaipal, 2001; Lemke, 1990). This feeling about biology

vocabulary was likely a result of the ELL Biology teacher's context-based teaching practices.

Past research shows that ELLs have typically been overwhelmed by the amount of written text used within science courses (Carrier, 2005; Fang, 2006; Miller, 2009). High-level reading skills are seldom given direct instruction in high school courses. This practice places a burden on English language learners who are unfamiliar with words that have multiple uses in conversational and academic settings (Carrier, 2005; Fang, 2006; Jaipal, 2001; Shanahan & Shanahan, 2008). The ELL Biology teacher chose to use the biology textbook sparingly, relying primarily on teacher-created notes to help students summarize the critical information for each unit. This strategy meant that ELLs had limited interaction with extended scientific text and the academic language of text in this discipline.

Student perceptions of academic language were also likely affected by the teacher's oral lectures and explanations. She chose to use colloquial sentence structures rather than dense academic grammar specifically to help students understand concepts using stories instead of scientific "jargon." The ELL Biology teacher did not often parse how words such as *synthesis* have alternate meanings in science and humanities, but she did break down scientific words into relevant prefixes and roots if she felt it added to a word's meaning. She therefore recognized that words and word fragments could carry multiple meanings, but did not emphasize those differences very often. If the teacher had required her students to rely more on the textbook or if she had chosen to employ more academic language from biology into her lessons, student impressions of academic

language may have been affected differently. This in turn may have influenced student perceptions of the tool's utility as a vocabulary study aid.

Directions for Future Study

This small-scale study focused on perception, but can be used as a basis for future research in the areas of mobile learning, study habits, and vocabulary development. The ideas outlined below demonstrate possible directions for future research.

Expanded awareness of study culture. Initial student interviews asked participants to recall their memories of school in their native countries, as well as their current study habits outside of school. Their responses indicated that it is possible that study skills were never taught in their native country schools or modeled by their parents at home. It may also be likely that the limited educational technology found in their native country schools did not adequately prepare them for integrating technology into their study habits, impacting their ability to multitask effectively. Students' school/study culture may have affected individual perceptions about the vocabulary tool's usefulness, especially with students who expressed their distaste for any science education. Expanding this study to include qualitative interviews with a larger sample of ELLs could provide some answers to these speculations, but should also include data collection from parents and guardians as well as students in order to obtain a more thorough recollection of events from life at home and their native countries. These data, when combined with post-study perceptions of the vocabulary tool, may offer greater insight into how individual backgrounds and attitudes about school influence the adoption or rejection of certain study resources.

Latin-based languages. The small sample of students participating in this study represented a wide variety of linguistic and academic backgrounds. Because biology vocabulary uses Latin roots, it may be possible that students from Latin-based languages have a better experience with the vocabulary tool due to the high number of cognates in Spanish, Portuguese, French, or Italian. Students from these language backgrounds may have a more helpful learning experience than students who speak languages with no Latin cognates. A possible direction for future research could focus on groups of students from Latin and non-Latin languages to see if there is any difference in vocabulary tool perception or use.

Continuing work with the ELL Biology teacher. The ELL Biology teacher reported that she made little effort to promote the mobile vocabulary tool as a study aid, however her final interview showed evidence that she would consider using it more in the future to supplement her students' study resources. This consideration revealed her perception that students needed more modes for interacting with content outside of the classroom. She recognized that students' attraction to gadgets could provide a way to influence their study habits in a way that traditional independent study could not. Her role as the course instructor means that she is in a position of influence about how importance of the vocabulary tool is portrayed. Her decision to promote online quizzes and after-school reviews may have affected her students' perceptions of the tool's usefulness. Having the ELL Biology teacher promote these three study options equally could be a direction for expanding this research and offering a more complete picture of participants' perceptions of the effect of mobile learning and study habits.

Furthermore, following up with this teacher after her next academic year could be another way to expand this study and offer a more complete picture of her perceptions of the tool's effect on study habits. Revisiting this teacher a year later could provide deeper insight because it is possible that the ELL Biology teacher may have a different perception of the tool if it were to be introduced earlier in the year. Because the tool was introduced so close to the end of the year—and therefore so close to the state standardized exam—she may have felt pressured to adhere to practices that she knew resulted in positive outcomes rather than taking a risk promoting a new, untried study resource. If the tool was introduced at a time when there was less anxiety to succeed, such as the beginning of the third quarter instead of the fourth quarter, both the ELL Biology teacher and her students could use the extra weeks to become comfortable integrating the review tool into their arsenal of study resources. A follow-up study could explore if developing this familiarity with a new study behavior earlier resulted in any changes in either student or teacher perception.

Working with a Technology-Oriented Biology Teacher. The ELL Biology teacher recognized that she was not particularly skilled in technology applications. Because she did not own a smartphone or iPod herself, this lack of familiarity may have affected her reaction to the vocabulary tool and her willingness to engage with it. It is possible that a different teacher, someone who was more familiar with new technologies, would be more enthusiastic about promoting the mobile vocabulary tool as a study option. Recreating this study at another school site with a different ELL Biology teacher could produce different outcomes from the results detailed in my research.

Revise the mobile vocabulary tool. Another possible course for future research could be to modify the mobile vocabulary tool to better correspond with student needs. Students referred to the small size of their iPods and the quick pace of the vocabulary tool as two reasons for not frequently using it. The size issue could be resolved by expanding the tool to fit other mobile platforms, such as tablets or mobile phones with larger screens.

Adding a Settings menu could allow users the option of turning the game timer on or off so that there was less pressure to choose an answer quickly. A Settings menu could also allow users the options to select or deselect specific biology units, giving the user greater control over which vocabulary to review. If the tool were introduced earlier in the year rather than in the fourth quarter, students could use this option to focus on their current unit of study rather than having the program pull questions from superfluous units. Giving students the options to tailor not only which mobile device they could use but also how they could align the tool with their specific needs could enhance the tool's effectiveness and increase its appeal as a study option.

The ELL Biology teacher indicated that she did not favor the mobile vocabulary tool as a study option because it did not allow her to track students' progress. This concern could be addressed with the addition of a login feature for individual students. If a student's work could be tracked in a manner similar to Blackboard's, teachers may be more inclined to promote the vocabulary tool to students.

Finally, the tool could be more useful if the database of questions was expanded to include other science subjects. If other teachers could contribute questions about

chemistry, physics, or earth science vocabulary, English language learners could have a tool to scaffold their language learning across multiple years. Not only could this enhance their ability to learn scientific language independently, it could provide continuity as they progress from one science class to another. Familiarity with the study tool may increase the likelihood that students will choose to use it to study appropriate vocabulary.

Conclusion

As computing devices become smaller and more portable, teachers and students will likely venture into new areas of technology to meet ever-changing educational demands. It is essential that mobile devices receive the attention that other technologies such as laptop computers have received. This study should be considered a path to learning more about best practices for using mobile technology to teach English language learners. It was conducted with a small number of participants over a short period of time, which limits the ability to generalize the findings to larger populations, but the data can be used as a future basis for replicated and extended research. In addition, the data contained within this study are not static. The codes and categories are the viewpoint of one researcher who knew each participant before the study began and worked to build a tool that would meet their vocabulary requirements. It is possible that another researcher with less personal involvement may come to different conclusions using the same qualitative interview data.

Findings from this study offer applications that are useful opportunities for progress into mobile learning and academic language development. Teachers who wish

to adapt their biology curriculum to include more technology resources may see a learning impact if they add the mobile vocabulary tool to their stock of review methods. They may also benefit from reading the ELL Biology teacher's insight into her teaching philosophy and practices. Also, educators seeking to understand the educational backgrounds and perceptions of adolescent ELLs may find this research to be a valuable glimpse into authentic student narratives on language and metacognition. Finally, educators considering mobile learning as an option for their schools may find the student and teacher perceptions in this study to be useful information about real-world application of mobile learning tools.

APPENDIX A
PRIMARY INTERVIEW QUESTIONS

**Note: These do not include extension questions or questions that were tailored for individual students*

Student pre-study interviews

The following script was used to begin each student before-interview.

"Thank you for coming today. As I explained to your class earlier, this interview is part of my research project at George Mason University. I am studying how ESOL students studying biology use their iPods to review science vocabulary. You recently took a short biology vocabulary test that will give me an idea about the biology words that you know now. That was the first part of the information I will be collecting about you. This interview will be the next part.

Before we begin the questions, it is important that you understand that anything you say here will be private. I will hear it, as will your group partner(s), but your teachers, counselors, and administrators will not hear or learn about anything you say. Because your privacy will be kept, it is important that you try to answer each question honestly. The things you say here today are very important, so be sure to think about your answers carefully. I want to know your true ideas and opinions, even if you think they make you look bad. That is the only way we are going to learn. If you don't understand something I ask, please feel free to ask me questions.

I am recording this interview so that I can study what you have said, but no one will hear these recordings other than me. You can see the recorder here in front of you. To make sure you are recorded, please speak clearly and try to wait until the other person has finished speaking before you begin. I want to hear your opinions, but I also want everyone to be polite and respectful."

Student pre-interview questions

1. I know you went to school in a different country before coming to this school. Can you tell me about you studied science in your country?

2. I'm also interested in how your study habits have developed since starting school here in the U.S.A. Can you tell me about some changes you've made?

3. What are some things you like and dislike about studying science?

4. Imagine that you have a vocabulary test coming up for biology. What would you do to study those vocabulary words?

5. Do you study biology vocabulary any differently than vocabulary for other classes?

6. Have you ever used a computer to study? Can you describe how you used it?

7. Sometimes it's possible to study using information from your iPod or text messages. Would studying on these devices be something you might want to do? Why?

8. Have you ever used an iPod to study? Can you tell me more about that?

Student post-interview questions

1. When we talked before, you mentioned some techniques that you used to study for science. Have those techniques changed at all over the last quarter? How?

2. From the weekly questionnaires, I see that you played/didn't play this game often. Why?

3. Tell me why using this game appeal/not appeal to you. How did you use this game? Can you tell me some things you liked or disliked about the game?

4. When you used this game, did it motivate you to look at/consult material from other sources, such as a textbook, notes, or a friend?

5. Do you think that using this iPod app helped you to recognize more biology vocabulary words than you knew before?

    Do you think it helped you use more vocabulary words in speaking and writing? Can you explain why you think so?

6. Do you think you will use more computers/iPods as you continue as an Oakton student?

7. If you could change anything about your study habits this year, what would it be?

8. Imagine that your friend will be taking biology next year. What advice would you give them about studying for this class?

Teacher pre-study interview

The following script was used during the initial interview with the teacher participant.

"Thank you for coming today. This interview is part of my research project at George Mason University where I am studying how ESOL students studying biology use their iPods to review science vocabulary. The purpose of this interview is to collect information about your experiences and opinions as the teacher of ELL Biology in this school. This interview will take about one hour to complete.

Anything you say in this interview will be completely private, so please feel free to answer all questions with complete honesty. Nothing you say here will be communicated to your colleagues or the administration. Your identity will be disguised with a pseudonym in the final report. I am recording this interview for later review, but the recording will be erased after the data analysis is complete.

Please feel free to as me any questions if there is something you are unsure about."

Teacher pre-interview questions

1. The standardized test performance of ELLs in your biology class has been outstanding for the past several years. Why do you think that is so?

2. What are some challenges you usually encounter when working with ELLs in biology?

3. How do you introduce new vocabulary words?

4. How do you expect students to learn the vocabulary required for this course?

5. In your opinion, what are some effective ways that students can study for this class? What do you encourage the students to do when studying?

6. What role do you think technology has in classroom teaching?

7. What role do you think technology has in informal learning?

Teacher post-interview questions

1. Every year brings a new group of students with different challenges for learning biology. What were some particular challenges you encountered this year?

2. Despite these challenges that you mentioned, you still managed to teach the students quite a lot about biology. Can you describe some things you did when you hit 'rough spots'?

3. Over the last quarter, students have had access to a vocabulary review game on their iPods. Did you ever see students using this game to study? Did you ever encourage them to use it?

APPENDIX B
BIOLOGY VOCABULARY (PRE-STUDY TEST)

1. In living organisms, lipids function mainly as
    a. Sources of stored energy and transmitters of genetic information
    b. Sources of stored energy and components of cellular membranes
    c. Transmitters of genetic information and catalysts of chemical reactions
    d. Catalysts of chemical reactions and components of cellular membranes

2. The building blocks (monomers) for proteins are
    a. Nucleotides
    b. Amino acids
    c. Monosaccharides
    d. Fatty acids

3. Which of the following organic compounds is the main source of quick energy for living things?
    a. Proteins
    b. Carbohydrates
    c. Nucleic acids
    d. Lipids

4. The cell membrane's outer surface is
    a. Hydrophilic
    b. Hydrophobic
    c. Isotonic
    d. hypertonic

5. What captures energy from sunlight during photosynthesis?
    a. Cuticular cells
    b. Stomata
    c. Chlorophyll and other pigments
    d. Carbohydrates

6. The process of photosynthesis ultimately converts light energy into
    a. Mechanical energy
    b. Chemical energy
    c. Electrical energy
    d. Nuclear energy

7. A mutation that involves one or a few nucleotides is called a(n)
   a. Chromosomal mutation
   b. Point mutation
   c. Inversion
   d. Translocation

8. The enzymes that unwind and unzip DNA are called
   a. DNA catalases
   b. DNA polymerases
   c. DNA helicases
   d. RNA polymerases

9. During transcription, the genetic information for making a protein is “rewritten” as a molecule of
   a. Messenger RNA
   b. Transfer RNA
   c. Ribosomal RNA
   d. Translation RNA

10. DNA made from combining the DNA of two or more organisms is called
   a. Gene therapy
   b. Forensic science
   c. Recombinant DNA
   d. PCR

11. The failure of chromosomes to separate during meiosis is called
   a. Non-disjunction
   b. Turner’s syndrome
   c. Mitosis
   d. Down syndrome

12. All the genes of all members of a particular population make up the population’s
   a. Relative frequency
   b. Genotype
   c. Phenotype
   d. Gene pool

13. Which of the following statements describes the process of natural selection?
   a. Farmers select animals with desirable variations for breeding
   b. Populations sharing the same gene pool interbreed and create new species
   c. Individuals that have inherited traits adapted to their environment survive
   d. New species are formed via genetic engineering

14. Where are you most likely to find an autotroph?
    a. In leftover food in your refrigerator
    b. In the darkness of the ocean
    c. In your digestive system
    d. Near the surfaces of lakes, streams, and oceans

15. A typical virus consists of
    a. A protein coat and a cytoplasm core
    b. A polysaccharide coat and a nucleic acid core
    c. A carbohydrate coat and a nucleic acid core
    d. A protein coat and a nucleic acid core

16. An organism that is a primary consumer is also known as a(an)
    a. Herbivore
    b. Carnivore
    c. Omnivore
    d. Autotroph

17. The types of major ecosystems, characterized by similar climate (i.e. deciduous forest, tundra) are referred to as
    a. Biospheres
    b. Biomes
    c. Communities
    d. Populations

18. To compare the relative ages of fossils, scientists sometimes use an easily recognized species with a wide geographical distribution. This organism is called a
    a. Extinct species
    b. Index fossil
    c. Radioactive fossil
    d. Half life

19. A cell that contains 2 copies of each chromosome is called a
    a. sperm cell
    b. egg cell
    c. haploid cell
    d. diploid cell

20. The cycle of viral infection that includes replication of the virus and cell destruction is called the
    a. lysogenic cycle
    b. lytic cycle
    c. metabolic cycle
    d. conjugation cycle

APPENDIX C
BIOLOGY VOCABULARY (POST-STUDY TEST)

1. The place on the enzyme where the substrate attaches to the enzyme is called the
    a. Active site
    b. Substrate
    c. Dehydration site
    d. Digestion

2. A covalent bond is formed as the result of
    a. Transferring electrons
    b. Transferring protons
    c. Sharing protons
    d. Sharing electrons

3. Isotopes are atoms of the same element with the same number of protons and
    a. A different number of molecules
    b. A different number of electrons
    c. A different number of neutrons
    d. The same number of neutrons

4. The cell wall of plants is made of
    a. Lipids
    b. Glycogen
    c. Wax
    d. Cellulose

5. Diffusion is the movement of molecules from
    a. An area of equilibrium to an area of high concentration
    b. An area of low concentration to an area of high concentration
    c. Across the membrane using ATP energy
    d. An area of high concentration to an area of low concentration

6. If a red blood cell is placed in salt water, the cell is said to be in a(n)
    a. Isotonic solution
    b. Hypertonic solution
    c. Hypotonic solution
    d. Equilibrium solution

7. The presence of what organelle would identify an organism as an autotroph?
   a. Nucleus
   b. Chloroplast
   c. Mitochondria
   d. Cytoplasm

8. The cell cycle is the
   a. Series of events that cells go through from “birth” to reproduction
   b. Period of time between the birth and the death of a cell
   c. Time from prophase until cytokinesis
   d. Time it takes for one cell to undergo mitosis

9. Small circular DNA molecules found in the cytoplasm of bacteria, in addition to regular DNA, are called
   a. DNA bands
   b. Plasmids
   c. Hybrids
   d. Clones

10. Organisms with genes from other species are called
   a. Clones
   b. Hybrids
   c. Transgenic organisms
   d. Mutants

11. What process makes identical copies of organisms?
   a. PCR
   b. Fingerprinting
   c. Cloning
   d. Gene therapy

12. Inbreeding and Hybridization are all examples of
   a. Natural selection
   b. Selective breeding
   c. Cloning
   d. Gene therapy

13. A karyotype can reveal which of the following?
   a. Age
   b. Sex
   c. Albinism
   d. Size

14. Condition in which two or more genes influence one trait is said to be
    a. Polygenic
    b. Pleiotropic
    c. Homozygous
    d. Co-dominant

15. The structural changes that occurred in certain plants over time allowing them to survive and thrive in dry habitats, are examples of
    a. Adaptations
    b. Nutritional relationships
    c. Predator-prey interactions
    d. Homologous structures

16. An important role of fungi in an ecosystem is
    a. Photosynthesis
    b. Making alcohol
    c. Breaking down dead organisms
    d. Killing bacteria

17. A pathogen is an organism that is
    a. Harmful to living organisms
    b. Beneficial to living organisms
    c. Harmful only to plants
    d. Almost extinct

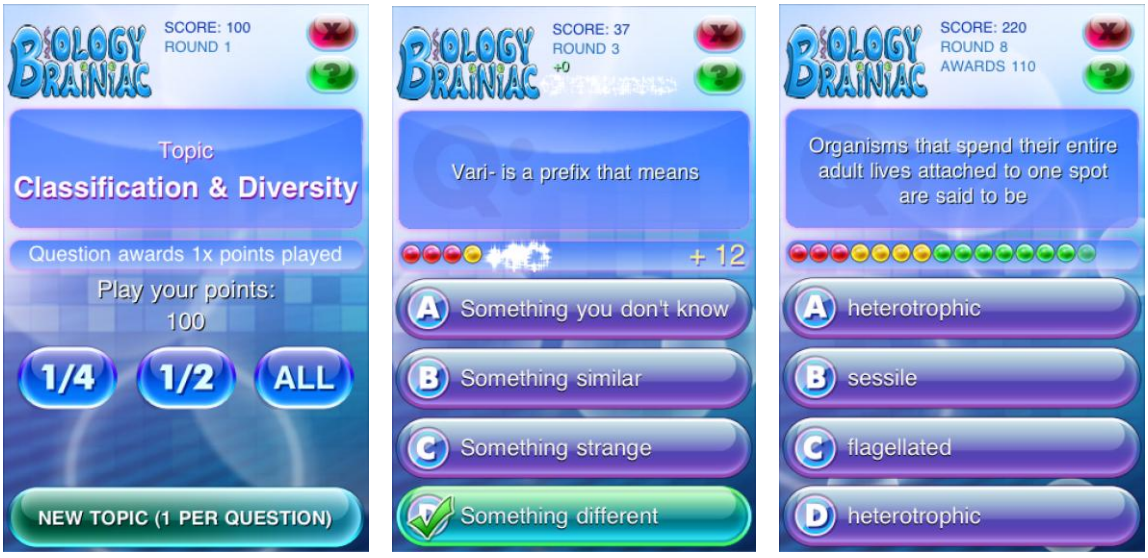
19. An organism that is able to use inorganic compounds to produce energy rich molecules is known as:
    a. Consumer
    b. Heterotrophy
    c. Parasite
    d. Autotroph

20. When CO_2 traps heat from the sun within the atmosphere, this is known as (the)
    a. Pollution
    b. Acid rain
    c. Greenhouse effect
    d. Ozone depletion

APPENDIX D
BIO BRAINIAC

The mobile vocabulary tool, **Bio Brainiac**, was developed as public service by Megatouch and its parent company, AMI Entertainment (all rights reserved).

Bio Brainiac can be downloaded for free from the Apple App Store.



APPENDIX E
WEEKLY QUESTIONNAIRE

How many rounds of Biology Brainiac did you play yesterday? (circle one)			
0-1 rounds	2-3 rounds	4-5 rounds	more than 6 rounds
In the past week, do you estimate that you have you played this many rounds each day?			
No, I usually play <u>more</u> than this.	No, I usually play <u>less</u> than this.	Yes, this is what I have played each day this week.	
Do you have any information you would like to share about Biology Brainiac?			
Something I like about Biology Brainiac is…	A problem I have with Biology Brainiac is…		

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CURRICULUM VITAE

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