



The Potential for Building High-School Students' Vocabulary Using an iPod Touch and Gaming App

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Abstract

This study focused on the potential for building 25 high-school students' word knowledge by using a mobile learning device and gaming app. Using a game as an instructional tool is a portable way for students to engage with content. The amount of vocabulary mastered after using the app on the mobile device was examined in relation to a pre-test and a post-test, completed 3 weeks apart. The aspects investigated were the transfer potential of learning on a mobile device, and the variation in performance levels. The results indicated a direct correlation between the pre-test score as a predictor for the post-test score. Also, the choice of techniques used to play the app indicated that participants called upon the 'process of elimination' and 'roots/word parts' as tools to help them master the vocabulary. These findings point to the potential for incorporating a game as an instructional tool for vocabulary development.

Keywords: mobile devices; gaming; vocabulary; high-school students

Introduction

As technology evolves, so must the use of technology tools in education (Facer et al., 2004; Rosen, 2010). Innovations have led to the development of mobile-device software that enables informal learning to take place anywhere and at any pace. Of particular interest is the iPod Touch gaming application (hereafter 'app') called the Vocab Challenge. This app supports mastering specific words in a variety of contexts such as definitions, synonyms, antonyms, and connotations. This study examined how a mobile learning device, along with a vocabulary app, might establish a rich gaming environment that is conducive to acquiring words that are frequently found on the Scholastic Assessment Test (SAT) taken by many American high-school students. In the literature review, we investigate the theoretical foundation for the app's design as it relates to gaming and good game design characteristics. The use of a mobile device and the possibilities for learning in an informal environment are further investigated as a tool to extend the vocabulary development that can help high-school students in later educational scenarios.

Literature review

Theory of gaming

The use of gaming as a pedagogical tool is well established. However, using mobile devices, which allow individuals to learn at their own pace and in their own time, is a new development. Lenhart (2009) notes that 74% of United States teenagers aged 12–17 own an iPod or MP3 player. Nearly 97% of United States teenagers play games on a console, mobile device, or computer (Lenhart et al., 2008). Behind the activities and actions of a game rests a theory of gaming. Botturi and Loh (2008) say “within game theory, the structural elements of a game exist as rules, turns, collaboration and competition, where winning, or fun, is modeled as numerical payoff. Game theory tries to explain *how playing (a game) works*, and defines games as an interactive process striving toward payoff” (p. 7). Thus a game provides the overall structure for reaching a goal (Provenzo, 1991). The goal is the intended outcome of interacting with the game, which leads the player to acquire knowledge, perfect a skill, solve a problem, or modify an attitude (Steinberg, 1991). The goal that is to be achieved in the game should be aligned with the activities that have to be completed to keep the player playing (Shelton, 2007).

Games limit the amount of time, space, and resources a player encounters so that they use problem-solving strategies to find solutions (Holland, Jenkins, & Squire, 2003). Games need to provide a unique balance of challenge and inquiry without being so difficult that they cause frustration. Game theory links game design and learning as a way to test frameworks for understanding (Holland et al., 2003). Every action requires the participant to think about their course of action, choose what to do, experience the action, and then reflect on that action before making future decisions (Paras & Bizzocchi, 2005). The decisions result in formulating branches that create new paths to progress through the game (Poundstone, 2006; Salen & Zimmerman, 2004).

Components and features necessary for good game design

Crawford (1984) explains that there are four components essential for designing a game: *representation*—a closed formal system where there are rules; *interaction*—actions while in the game; *conflict*—struggles endured while facing obstacles; and *safety*—a safe way for real-life activities to be experienced. Successful games usually encourage active discovery learning while providing a unique balance of competitiveness and enjoyment (Blachowicz & Fisher, 2008; Child, 1993; Gee, 2008). The most successful gaming programmes are learner initiated, learner controlled, and intellectually engaging (Jonassen & Reeves, 1996; Nitsche, 2008).

Ryu and Parsons (2009) note that active participation in learning allows the learner to test ideas and approaches based on their prior knowledge and experiences (feedback)—they can then apply this knowledge to new situations. Feedback is a message presented once a response is made, and includes providing overall results, correct answers, and a rationale for why a response is wrong (Child, 1993; LeBlanc, 2006; Steinberg, 1991). The feedback provided in games allows for the development of skills that can be transferred either to later scenarios in the game, or to operational environments (Dempsey & Sales, 1993). Games therefore allow for remediation to take place depending on the responses generated (Steinberg, 1991). If a player is challenged or makes an incorrect choice, they can rehearse alternative approaches based on the feedback, and so learn from their mistakes (Holland et al., 2003).

Gaming as an informal learning environment

Gaming brings about new learning opportunities for students. Shaffer, Squire, Halverson, and Gee (2005) explain that games will not replace learning in schools, but will offer ways in which more powerful modes of learning can be incorporated anywhere and at any time. Computer and video games offer new approaches to learning material in an individualised, interactive, and guided environment (Child, 1993). Gaming environments give players chances to fail without the pressures of the external factors of grades and mandatory work (Botturi & Loh, 2008; Squire, 2005).

Informal learning occurs by engaging with intentional, but not too structured, activities that are completely controlled by the learner (Marsick & Watkins, 1990). Games on mobile devices support learning to happen anywhere by allowing learning to transpire in a combination of physical, digital, and communicative spaces (Facer et al., 2004; Rogers, 2009). Taking learning out of the structured environment of a typical classroom that has set time periods, and expanding it onto mobile devices that tap into the unrestricted realm of after-school time and weekends at any location, has the potential to engage learners even more (Bongey, Cizadlo, & Kalnback, 2006; Putman & Kingsley, 2009). Caronia and Caron (2009) reported that most (44%) use of iPods for academic purposes occurs at home. Engaging in educational activities on a mobile device helps to relate to the interests and needs of young people growing up in a technologically mediated environment, and offers opportunities for multitasking (Rosen, 2010).

Vocabulary development, word knowledge, and gaming

Terminology and words used in games can tap into a variety of content areas. Blachowicz and Fisher (2008) note “games and word play can provide a context in which students can enjoy word learning and develop word consciousness” (p. 50). Games provide a way for words to be presented in an organised manner that can extend the school day and amount of time spent working in a content area. Nagy and Anderson (1984) note that direct vocabulary instruction can cover only a small percentage of the words that children should actually know. An average high-school student knows 45,000 words (Pinker, 1994). This number is small in proportion to the number of distinct words present in language, which Nagy and Anderson (1984) estimate to be around 88,500. Vocabulary-enriched games might provide this extra support for learners to achieve success and build their vocabulary word bank.

Methodology

This study explored the growth and transfer of high-school students’ vocabulary from pre-test to post-test. The major research questions explored were:

1. How does a portable media device (i.e. iPod Touch) and a gaming application (i.e. Vocab Challenge App) affect high-school students’ vocabulary development and word knowledge over time?
2. How do certain word-study strategies influence students’ success in vocabulary mastery?
3. Based on high-school students’ self-perceptions, what effect does the use of a mobile device have on learning vocabulary?

Data collection tools

Four instruments were used to collect data from participants. Two surveys were administered: one at the beginning of the study and the other at the end. The first survey, *Vocabulary Acquisition via iPod Touch Survey 1*, gathered demographic information and technology-use characteristics about each participant. The second survey, *Vocabulary Acquisition via iPod Touch Survey 2*, gathered information about participants’ overall experience with the iPod Touch

and the Vocab Challenge app. Vocabulary tests were used at the beginning and the end of the study to discover each participant's knowledge and understanding of words. Each test contained 20 words. The vocabulary test was composed of words found in the app. There were five questions of each type (antonym, connotation, definition, and synonym) of equal difficulty level on each test. The difficulty levels were based on a group of university students ($n = 62$) that took a 40-item vocabulary test, which was then broken down, analysed, and separated into two tests (pre-test and post-test). Cronbach's alpha was computed to test for reliability, resulting in a reliability coefficient of 0.65 on the pre-test items and 0.62 on the post-test items, and meeting the minimally acceptable level (>0.60) of consistency among items (Klassen, 2004). The fourth instrument was a daily log form that participants used to keep track of their use of and progress with using the Vocab Challenge app.

Participants

The participants were enrolled at one of two high schools, *High School 1* and *High School 2*, in neighbouring towns. Students in these two high schools were targeted because of their locations relative to the university researchers who conducted the study. *High School 1* was a large suburban high school with approximately 1451 students in grades 9–12. *High School 2* was a small rural high school with approximately 360 students in grades 9–12. Thirty-one students volunteered to participate in the study. Once the data were collected and reviewed, it was revealed that six participants did not log any use of the iPod Touch and app. These participants were excluded from the data analysis. This left a sample of 25 students (9 males and 16 females). From this sample, 11 (3 male and 8 female) belonged to *High School 1* and 14 (6 male and 8 female) belonged to *High School 2*. The participants' ages ranged from 14 to 17, with an average age of 16. Most participants were in 11th grade: 8% ($n = 2$) in 9th; 24% ($n = 6$) in 10th; 60% ($n = 15$) in 11th; and 8% ($n = 2$) in 12th. Most participants were Caucasian (68%) (see Figure 1).

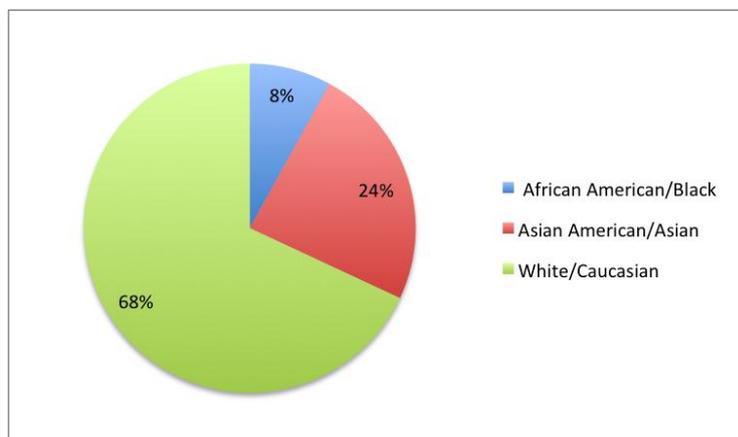


Figure 1 Ethnic background of participants ($n = 25$)

Research procedures

Participation in the study lasted for 3 weeks and involved two sessions. The researcher visited the two high schools, gave a presentation, spoke to school personnel, and handed out flyers. Interested students or school personnel then contacted the researcher to set up a meeting time. Before participation, each participant and one of their parents signed a consent form. The first session involved taking the 20-item, multiple-choice vocabulary pre-test and a brief online survey titled *Vocabulary Acquisition via iPod Touch 1*. The second session involved each participant completing the 20-item vocabulary post-test and a brief survey entitled *Vocabulary Acquisition via iPod Touch 2*.

Results

The first research question focused on the development of vocabulary that may have occurred during the study. The mean score for all participants (*High School 1* and *High School 2*) on the pre-test was 13.80 ($SD = 2.02$, $min = 9$, $max = 18$) out of a possible score of 20. The mean on the post-test was 14.16 ($SD = 2.81$, $min = 7$, $max = 19$) out of a possible score of 20.

Both tests contained five questions of each type (antonym, connotation, definition, and synonym). Figure 2 provides mean scores per question type on both the pre-test and post-test items. Participants experienced a slight decrease in their performance in the mean scores between the pre-test and post-test on the connotation and definition items. There was an increase in the mean score on the antonym items and a slight increase on the synonym items between the pre- and post-tests. Scores on the antonym post-test were 0.88 higher than on the pre-test. A t-test indicated there was a significant difference in the antonym pre-test and post-test items $t(24) = -3.23$, $p = 0.0018$. 95% CI : (-1.44, -0.32).

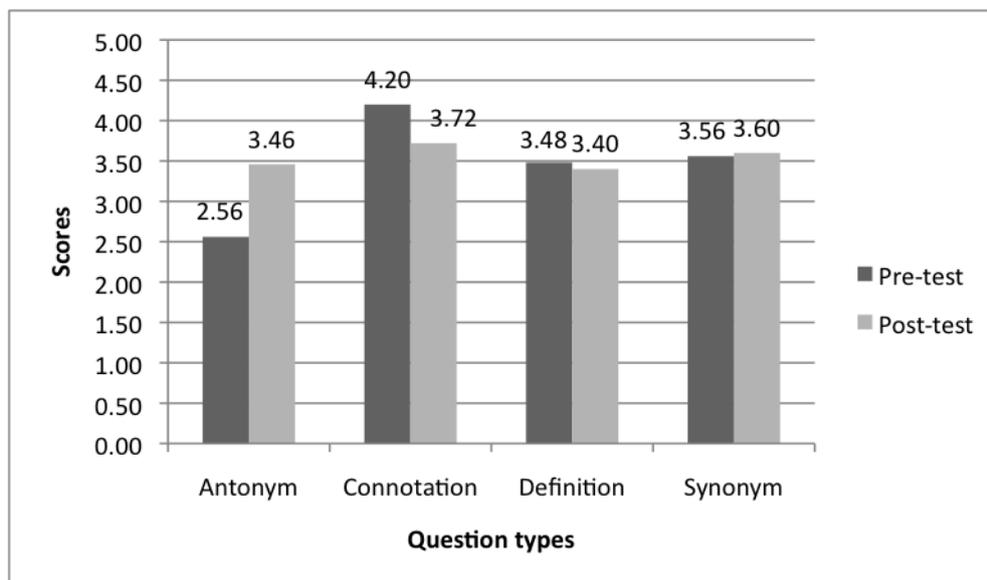


Figure 2 Participants' mean scores on the pre- and post-tests based upon question type

An ordinary least-squares regression analysis was calculated to determine the relationship between the dependent variable and several independent variables such as the pre-test score and the level of student engagement. To discover the overall level of student engagement, a principal components analysis was performed on the following survey items denoting students' emotions: 'bored', 'challenged', 'confused', 'frustrated', 'pressured', and 'satisfied'. These emotions were rated on a five-point frequency scale from 'never' to 'always'. A graph of the proportion of variance indicated that these variables fell primarily on three components, thus 'confused' (0.71), 'satisfied' (-0.75), and 'challenged' (0.69) were calculated (Statsoft, Inc., 2011). Together, the components created a level of student engagement. For each component, the measures were combined to result in a score for each participant (Decoster, 1998).

The regression was run with the dependent variable of the post-test score, the independent variables of the pre-test score, and the 'confused', 'satisfied', and 'challenged' variables. The regression indicated that the pre-test score was a significant predictor of the post-test score: $b = 0.77$, $t(24) = 2.98$, $p = 0.007$. This indicated that depending on the score earned on the pre-test would result in a 0.77 increase on the post-test, $R^2 = 0.42$, $F(4, 20) = 3.55$, $p = 0.0241$.

The app itself tracked specific information relating to game play; that is, the percentage of performance on each game and the number of words students encountered while using the app. The percentage performance for each game was combined and averaged for all participants to give them an overall performance level within the app (see Table 1).

Table 1 Game performance (reported as percentages)

Game type	Participants' game performance	
	M	SD
Definition game	56%	0.12
Antonym game	60%	0.17
Synonym game	68%	0.14
Connotation game	74%	0.09
Average performance on the app games	65%	

A regression examined the potential relationship between the post-test score (dependent variable) and the two items that were tracked through the app (independent variables). The performance average of the games in the app significantly predicted the post-test scores: $b = 0.10$, $t(24) = 2.27$, $p = 0.033$. This indicated that for every one unit increase in the performance average, there is a 0.10 point increase in the post-test score if all other explanatory variables are constant.

Influence of word study strategies on vocabulary mastery

The second research question examined the types of word study strategies ('guessed', 'learned at school', 'process of elimination', 'roots/word parts', 'remembered it from the summary page', 'remembered it from another game') that students used to master vocabulary. Based on a six-point frequency scale ranging from 'never' (1) to 'very frequently' (6), participants ($n = 25$) rated the word study strategy they used most frequently: 'process of elimination' the most ($M = 4.60$), then 'guessed' ($M = 4.24$), which was followed closely by 'roots/word parts' ($M = 4.20$).

The third question focused on participants' self-perceptions of their learning experience with a mobile device. These questions centered on the aspects of mastery learning and active learning. Each statement was rated by participants using a five-point scale ranging from 'strongly disagree' (1) to 'strongly agree' (5). Overall, participants tended to agree that they remembered the words more by working with them in four ways ($M = 3.88$) and that they felt actively involved in their learning by using the touchscreen and shaking the iPod ($M = 3.60$). However, the participants were not confident ($M = 3.28$) that they had mastered the words using the app.

The level of difficulty experienced by the participants while using the iPod Touch, and the various activities within the Vocab Challenge app were analysed to see what effect this may have had on performance. Based on a seven-point scale ranging from 'very difficult' (1) to 'very easy' (7), participants did not report having any difficulty navigating the iPod Touch. Overall, the participants found the difficulty level of the app quite low (see Table 2).

Table 2 Difficulty rating of app design

Item	Level of difficulty	
	M	SD
Navigating the iPod Touch	6.56	0.58
Playing the app overall	6.20	1.00
Understanding the rules of the definition game	6.50	0.66
Understanding the rules of the antonym game	5.76	1.36
Understanding the rules of the synonym game	6.20	1.12
Understanding the rules of the connotation game	6.32	0.95
Navigating the pages	6.24	0.78
Reading the font	6.50	0.73

Discussion

The participants' experiences gave an insight into using educational mobile games as a tool for informal learning. The participants engaged in the use of the gaming app primarily in three locations: home, car/bus, and school/study hall (from most frequent to least reported), for varying amounts of time during the 3-week time period. The aspects of informal learning, mastery learning, transfer, and engagement all emerged as contributing factors to the results.

Informal learning

The results indicated that there was a slight positive association between the score on the pre-test and the score on the post-test. This may be due to the fact that participants entered with differing prior knowledge. For example, those from *High School 1* had an average grade-point average (GPA) of 3.96 out of 4.00, whereas participants from *High School 2* had an average GPA of 3.57 out of 4.33. Every person has a different composition of vocabulary that connects with previous experience and knowledge (Pearson, Hiebert, & Kamil, 2007). The difference in the amount of participants' prior knowledge may have played a role in the number of words correctly identified on the two tests, resulting in no significant difference between the performances on the two tests.

Further information was gathered on the specific items on the pre-test and post-test. The questions were analysed according to the type of question (definition, antonym, synonym, and connotation) presented in the app. The definition and connotation question scores did not increase from the pre-test to post-test. This finding indicates that knowledge of the words (definition and connotation) was not achieved before the participants took the post-test. The words may not have been encountered for a few reasons. The fundamental property of informal learning is to allow learning to happen anywhere and anytime (Shaffer et al., 2005). The individualised and self-guided experience within the gaming environment allowed the participants to work at their own pace whenever they had free time. One limitation of this study was that the window of game play was only 3 weeks, and the amount of time the participants spent on the app varied greatly. Graves (2008) explains that students should work with a word more than once to aid in vocabulary building. Some participants self-reported only a small amount of time using the app, thus limiting the amount of interaction with the words between the two tests. Some only used the app for 10 minutes, whereas others used it for 500 minutes. This large variation in the time spent interacting with the words could account for the large standard deviation (2.81) in the post-test scores.

Another important component that relates to the amount of time students spent on the app is the aspect of self-reporting. After each game-play session, participants were instructed to record the amount of time the game was played, to the nearest 5 minutes. They were also to record the number of words encountered within the app (this number was cumulative). The amount of time positively correlated (0.61) with the number of words encountered. Unfortunately, the self-report aspect limited the precision provided by this recording measure. Since this type of data could not be verified by an external validation measure (the number of words that should be mastered during any given time period), the number of minutes and words encountered across all participants were analysed. As a result, discrepancies were found. For example, one participant noted using the app for around 20 minutes, encountering 78 words; whereas another, who also recorded 20 minutes, encountered 635 words. This also occurred at the high end— one participant recorded 230 minutes and encountered 2,457 words, whereas another participant who logged 10 minutes more (240) encountered only 938 words. The lack of a consistent and built-in timer in the game may have skewed the amount of time played and how this related to the number of words encountered.

The game was built on the principles of mastery, which could only be achieved by interacting with a word in four games and correctly answering the questions relating to it (Modality, 2010). To explain the level of mastery and active participation in the learning process, the participants answered three questions. The participants agreed ($M = 3.88$) that working with the words in four ways helped them to remember the words. This rating indicates that the repetitive nature of interacting with the words helped the students to remember them. However, participants were then asked if they felt they had mastered the words by using the app. Participants rated this as neutral ($M = 3.28$). Gee (2008) explains that within the gaming environment the player needs to become an active participant to gain the full learning experience. If the participants did not feel they were actively involved in the learning experience, they also felt that they had not mastered the vocabulary words. Thus, most participants in this study did not really feel the app helped them master the vocabulary words, and that conclusion was reflected in the small difference between the pre-test and post-test results.

Vocabulary mastery

The level of commitment and investment in the learning process was reflected in the techniques that were frequently used to play each game. Vocabulary acquisition requires a variety of techniques and methods (Nagy & Anderson, 1984). The three techniques used most frequently by participants in this study were, in descending order: ‘process of elimination’, ‘guessed’, and ‘roots/word parts’. ‘Process of elimination’ was the strategy that the app maker, Modality, and the Princeton Review had designated and promoted as the strategy to use, and the result of ‘frequent use’ correlates with this purpose (Modality, 2010). Another strategy used was ‘roots/word parts’. Participants may have learned this technique by using Scholastic Assessment Test/American College Testing study materials, or in high-school English classes. Association based on previous encounters and connections with other words can help to build up vocabulary (Murphy, 1991). The other strategy participants used was ‘guessing’. If participants were guessing, it’s possible that no true vocabulary mastery occurred during the study. Guessing may have occurred during the game play because the participants encountered 20 words before they received corrective and informational feedback. The variation in the participants’ strategies displayed the potential provided by informal learning, where the learners use the learning techniques that they deem suitable to meet the goal. Knowledge gained informally on a mobile device can transfer to the formal environment (Pachler, Bachmair, & Cook, 2010). It is possible, therefore, that the fluctuation in use of the strategies may be related to the strategies the learners had already learned.

Transfer

Learning new vocabulary can be done through games, repetition, and practice. Gee (2005) noted that good games actively involve players in the experience through their actions and decisions. Successful games offer a combination of active and enjoyable learning experiences (Blachowicz & Fisher, 2008; Child, 1993; Gee, 2008). The participants' overall app score (combination of the antonym, connotation, definition, and synonym game scores) had a significant relationship with the post-test score. By actively engaging in the games on the app, the participants increased their scores on the post-test. This implies that their learning experiences using the app were transferred to a new environment (taking a test). Transfer involves linking one experience to another—if the participants gained vocabulary knowledge experience from the app, they would then be able to apply it to another scenario (Gee, 2003; Hunter, 1995).

The transfer of knowledge from the app to the post-test may be exemplified by the results on the post-test for the antonym game. Statistical significance was noted between the antonym pre-test score and the antonym post-test score, $t(25) = -3.23, p < 0.01$. Participants' self-reported game statistics ranked this game the most difficult and the least satisfying. This difficulty may have caused the participants to increase their attention during the game because they had to think about what the word meant and then determine which of the three options was the opposite. The interaction within the game may have reintroduced participants to the concept of an antonym and refined their ability to determine what an antonym is in a testing situation. This interactivity, player positioning, and choice may have contributed to the significant increase in the score for this type of question (Dickey, 2005).

Engagement

The participants' level of engagement varied throughout the study. The principal components analysis indicated that the factors of 'confused', 'satisfied', and 'challenged' were the most prevalent. A player's decisions in a game affect the future outcomes in the game (Nitsche, 2008). Participants who felt 'confused' from the beginning would have continued to transfer this feeling throughout their experience of the app. The participants' emotional rating indicated that, overall, they had a negative 'satisfied' level with the experience. The lack of intellectual engagement and a feeling of competition may have caused the participants to feel this way. Another reason for lack of satisfaction is associated with the third emotion exhibited: 'challenged'. A high level of difficulty may have led to participants feeling overwhelmed and choosing multiple incorrect answers, resulting in the reported emotions of being 'satisfied' and 'challenged'.

Using a mobile device provides a way to construct knowledge and gain meaningful experiences related to learning tasks (Rogers, 2009). As Blachowicz and Fisher (2008) explain, games and word-play provide a way to develop word knowledge. The results illustrate that the app can provide a vocabulary learning experience by promoting informal learning, mastery learning, transfer, and engagement.

Conclusion

Mobile devices give learners an opportunity to build their vocabulary knowledge at a pace that suits them. If encounters with words are repeated over time, there is some potential to develop a stronger, more robust vocabulary (Graves, 2008; Pearson et al., 2007; Pressley, Disney, & Anderson, 2007). The participants' prior vocabulary was a significant factor in their performance on the post-test. The time factor also contributed to the post-test results. Participants need time to interact with the words so that they can then transfer this knowledge from the device's simulated learning experience to practical uses in reading, writing, and testing activities—it is important to take this time into account.

The study had a few limitations. First, the number of students who could participate at any one time was limited by the number of devices (iPod Touch) available—both in terms of individual ownership and from the researcher. Second, the motivation for participation may have influenced participants' attention to detail when self-reporting the data. For example, all participants who provided an email address were entered in a draw for iTunes gift cards. This meant that, regardless of whether they used the app for 10 minutes or 500 minutes, participants had the same chance of winning the cards. For some, the lack of a specific amount of time required may have affected their motivation for using the app. This could be addressed in a follow-up study—still with a focus on informal learning—but with a minimum number of minutes to use the app. The game-play would vary across participants and the times and days used, but a minimum level may provide more motivation and engagement. Also, if this study is replicated, the lack of consistency of the self-reporting measure of time versus the number of words encountered should be investigated. If the software were updated to internally record the amount of time spent, the degree of inaccuracy in reporting this measure would be reduced.

Further research could explore the possibilities for transfer from the vocabulary used on this app. The type of vocabulary activities may also be investigated further; for example, antonym activities, which had an effect, versus other types of activities (connotation, definition, and synonym). As more schools implement one-to-one initiatives, portable devices are getting into the hands of learners in formal learning environments (Holcomb, 2009). However, the participants in this study did not generally own their own iPod Touch, and borrowing one and having to return it limits the potential for future and continued use with the vocabulary. This study took place in an informal learning environment, but future studies could investigate what would happen if the mobile device was also used formally, and whether this results in larger gains in vocabulary knowledge.

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