ABSTRACT

STUDENTS USING MOBILE PHONES IN THE CLASSROOM: CAN THE PHONES INCREASE CONTENT LEARNING

By

David Lee Rinehart

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A study was conducted at a high-performing school in Southern California to explore the effects on learning content from students using their own smart phones in and out of the classroom. The study used a Switching Replications design format which allowed two independent analyses of posttest scores between a group using e-flash cards on smart phones and a group using paper flash cards. Quantitative data was collected via two tailed, *t*-tests and qualitative data was collected through observations and interviews. Results suggest that knowledge level learning may be increased with mobile phone use, but no effect on comprehension level learning was found. Students found the phones to be convenient in accessing flash cards anytime and anywhere. Enthusiasm for using the phones in class while initially high waned over the 1 month study duration. Students perceived the phones to not be a significant source of distraction outside of class.

STUDENTS USING MOBILE PHONES IN THE CLASSROOM: CAN THE PHONES INCREASE CONTENT LEARNING

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Committee Members:

Alan Colburn, Ph.D. (Chair)
William Straits, Ph.D.
Suzan Gomez Zwiep, Ph.D.

College Designee:

Laura Henriques. Ph.D.

By David Lee Rinehart

B.S., 2003, California State University, Long Beach

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ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

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CHAPTER 1

INTRODUCTION

Have you ever wondered what it would be like to teach in a classroom where all students had their own personal computers? The ability to take pictures, video, browse the internet, send and receive e-mails, save data, download applications, and so much more? I know I have. Well that time maybe now and educators should look to this amazing potential known as the smart phone. According to NetDay, a national nonprofit group, in 2009, 70% of students in grades 6-12 used a cell phone either during school or on their free time (Project Tomorrow, 2009). Maybe more telling is that 67% of students in grades 9-12 have a cell phone and 31% have smart phones (Project Tomorrow, 2009).

Some educators around the country have put forth the idea that these phones, especially with the ability to text, are too great a distraction for students to be using in a classroom and that the phones should be banned (Bouchard, 2011). Other educators believe mobile phones can be valuable learning tools and are trying new ways to utilize them in lesson plans (Hartnell-Young & Vetere, 2008). Who's right? In this time of budget deficits and funding shortages, teachers and administrators alike must look for inexpensive and readily available technology to help motivate students and promote content learning. It is possible that the ubiquitous smart phone may be that technology. Therefore this study is designed to explore the educational potential of mobile phones in classrooms.

Qualitative research studies have explored students' and teachers' attitudes with regard to using mobile phones or other types of mobile technology in the classroom. Most of those studies only focus on perceptions and opinions of the students or educators on the phones effectiveness (Campbell, 2006; Cavus, Bicen, & Akcil, 2008; Hartnell-Young & Vetere, 2008). However, very few studies examine the actual use of the phones or their effectiveness for learning content. It is my hope that this study might shed light on whether using mobile phones during class time in a content driven manner has any effect on helping teenage students learn.

By using flash cards as the tool of instruction, whether on paper or a phone, my goal is to make the implementation of the content and the assessment as simple as possible. Biology as well as other science disciplines is vocabulary intensive and students if expected to learn science must also learn and understand science terminology. Flash cards have been shown to help with learning basic vocabulary for different subjects (Din and Wienke, 2001).

This research was conducted in a high school in suburban Southern California. The students were enrolled in a typical high school biology class and most were ninth graders. The participants came from mostly Caucasian, affluent families that live in or around the area, but some are of Asian descent with fewer still coming from Latino and African American ethnicities.

If any significant differences in content learning are found between students who use the phones and ones who use the paper flash cards, then it may be reasonable to suggest mobile phones can help students learn content better than more traditional methods (not necessarily as a replacement, but as a supplement). It is of course also

possible that no significant difference will be found between the treatment and control groups and if this is the case, then either different ways to use the phones in class should be explored or the phones simply don't make a measurable difference.

Research Questions

1. Does using flash cards on mobile phones increase content learning when compared to using flash cards on paper?

2. What are students' perceptions of using the mobile phones for learning content?

To test research question number one, two groups of students participated concurrently. The quasiexperimental method used is known as The Switching Replications Design (Best & Kahn, 2006). A graphical representation of this design can be found in Appendix A. To establish equivalent groups for an ecology unit and a cell unit, a pretest was given prior to the start of each two week unit. These pretests were 10 question, multiple choice assessments which then were analyzed by a two tailed *t* test to ascertain group equivalency. In the event of nonequivalency, outlier students would have been removed from the groups until equivalency was established. See Appendices B and C for these pretests.

Each pretest had five knowledge and five comprehension questions to stay consistent with the two posttests which were also composed of 15 knowledge and 15 comprehension questions each. See Appendices D and E for these posttests. All questions come from the Biology Standards Practice Test bank published by Prentice Hall (Miller & Levine, 2002). These questions were selected to tightly correlate with the

type of learning that flash cards facilitate, namely memorization and comprehension (Din & Wienke, 2001).

The treatment group made electronic flash cards that are stored and accessed via mobile phones during and outside of class to help enhance and possibly learn the content better. The control group did not use phones, but instead used paper flash cards. At the end of a two week unit a multiple choice, post assessment was given and the two groups were statistically compared to examine whether significant differences exist. Then the two groups switched roles, a new topic unit taught, another multiple choice posttest, and the results statistically analyzed again.

This Switching Replications Design was used to extend the treatment time, reduce nonequivalent group error, increase internal validity, allowed for two independent implementations of the treatment, and may have enhanced external validity as well (Trochim, 2006). This design also has the benefit of being ethically fair as both groups receive the treatment, not just the experimental group. The total number of students in each group was 32.

To test research question number two, participant observations were made during lessons with focus group interviews and in depth individual interviews of select students being conducted after each posttest. The observations and interviews were audio recorded to ensure accurate and complete transcriptions of interviews and observations, and to increase internal validity as a safeguard by asking the same questions in the same manner. The interview questions focused on student perceptions of the phone's effectiveness for learning, if they thought the phones had an educationally positive impact, and if they thought the phones were a distraction and detracted from learning.

The triangulation of observations, focus group interviews, and individual interviews helped ensure that data collected was as valid and reliable as possible.

Key Terms

1. Smart Phone: any mobile, hand held device primarily used for communication that can access the internet, download applications, text (SMS) and commonly equipped with a camera for taking video and still pictures. This could include iPads and tablets, but in this research study, only small, "fit in one hand" mobile phones are included.

2. Content learning: defined in this study as knowledge and comprehension levels from Bloom's Taxonomy. The questions on pretests and posttests all came from those two categories and the use of flash cards has been tied to memorization and comprehension. The students have learned content, as assessed in this study, if they remember and interpret concepts from paper flash cards or by electronic flash cards via the mobile phones.

3. Knowledge level learning: as used in this study, if a student can recall or remember the information. See appendix item F for examples.

4. Comprehension level learning: as used in this study, if a student can explain ideas or concepts. See appendix item F for examples.

CHAPTER 2

LITERATURE REVIEW

If this research study had been done ten years ago, the literature specifically surrounding mobile phone use in the classroom would have been very thin indeed. The last five years has seen remarkable growth in this area, but is still very new and lacking in substantive research that really gives educators and researchers useful answers. The following review of the current literature in the area of mobile phone use has been broken up into the following four major themes: seeking the current status of mobile phone use in schools, seeking new uses for mobile technology in schools, how participants perceive the usefulness of mobile technology, and linking knowledge and comprehension learning to mobile phone use. As you will see, little direct research has been done to test if mobile phones actually help a student learn the subject content more effectively or not.

Current Status of Mobile Phone Use in Classrooms

Froberg, Schwabe, and Goth (2009) conducted an extensive review of the then current domain of mobile learning which included conference proceedings, articles, and journals that focused on mobile learning and its applications. Very few of the hundred or so articles they reviewed had anything to do with how learners benefitted from mobile phone use. Much of the literature then was about different programs and devices available, but not in ways that talked about how the students could benefit. They concluded mobile learning should provide students with reflective and not just

knowledge gaining opportunities. In Kim, Holmes, and Mims (2005) article, most mobile learning applications at the time included nonassessment type studies and provided little evidence on student learning via mobile phone. Those applications included assignment calendars, contacts, and to-do lists, but not direct instruction support for the classroom. They concluded mobile wireless technology included the two benefits of mobility and convenience.

Cheung and Hew (2009) conducted a more focused review of the research and found that "mobile handheld devices are most commonly used by students and teachers as communication tools and multimedia access tools" (p. 165). They also suggest that students' learning is enhanced with the use of PDAs, but cautiously so and only related to language vocabulary learning. According to Cheung and Hew (2009), limitations on previous empirical studies suggest that almost half of the studies based their findings on self reported data gathered by interviews and questionnaires. They state that these methods alone are inadequate due to participant's responses having the tendency to make the respondent look good and not necessarily provide a true picture. For a study to adequately pursue the effects of content learning, clearly self-reporting by the participants is not enough.

Potential Uses for Mobile Phones in Classrooms

Chen, Hsieh, and Kinshuk (2008) support mobile phone use as a language learning platform through the context of culture. This study had the additional advantage of having data based on different levels of use by the mobile phones. For example, in learning new English words, some participants received just written annotation while others also received pictures to represent the words. They reported increased assessment

scores in learning English vocabulary words by Chinese students and found at least some of that attributable to the inclusion of pictorial annotations.

Campbell (2006) argued that much more research into how best to use the mobile phones is required before allowing the phones into classrooms. Too much potential for misuse and abuse exists with not enough support for continued use in a classroom. Students found ringing to be a distraction, but the younger the student, the less distractive it was (Campbell, 2006). It is worth noting that even though there is a down side to using mobile phones in a classroom, in my opinion, there can be many upsides.

In her book, Kolb (2008) suggests that mobile phones not only be allowed in classrooms, but that they should be incorporated into the lesson plans as much as possible. In her opinion, using the phones in the variety of ways that they can be used for (such as video and picture montages, texting activities, and podcasting) helps connect students' culture to the classroom and in doing so, makes learning more meaningful to the students. Also stated by Kolb (2008) a study of 1,500 students ages 10-17 in 2007 found that, according to the students, during the summer they spend an average of almost four hours a day on their mobile phones and that they would rather give up TV and video games than their phones. It seems safe to say that utilizing this zeal for education purposes is not a waste of time.

Participants Perceptions of Usefulness of Mobile Technology

Incorporating old with new literacies is also a theme rather played out in the literature as many authors have researched this new literacy of mobile phone use as it pertains to connecting a student's own cultural filter with that of new technology (Hartnell-Young & Vetere, 2008; Kolb, 2008; Milrad & Spikol, 2007). Hartnell-Young

and Vetere, (2008) conducted a half-year long study with four indigenous students in Australia and found that by using smart phones, some "students were able to cross boundaries between school and social contexts, and thus contributing their life experiences to school curriculum" (p. 328).

Lastly, when the use of mobile phones is integrated into the course curriculum driven by "pedagogical rather than technical reasons" (Rismark, Solvberg, Stromme, & Hokstad, 2007, p.1305), positive student learning activities can occur. Also important in students' motivation to learn with the mobile phones is a sense of ownership. If the phones are loaned and not owned by the participants, they are reluctant to invest money or time into personalization (Milrad & Spikol, 2007). Having the students use their own mobile phones, even if sharing at times, hopefully is a positive aspect of this study.

Linking Knowledge and Comprehension Learning to Mobile Phone Use

In the 1950s, a group of measurement specialists created a taxonomy of educational objectives to aid university faculty across the United States in codifying and sharing exam bank items to measure similar educational objectives (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). The taxonomy provided carefully developed definitions for each of six major categories in the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. With the exception of application, Bloom *et al.* (1956) further subdivided the categories into subcategories. The six initial categories have commonly come to be known as Bloom's Taxonomy (Bloom et al., 1956). Furthermore, it is commonly assumed that this taxonomy represents a cumulative hierarchy; in other words, before mastering a more complex category, the preceding simpler one must be mastered first (Krathwohl, 2002).

In this study, the first two categories of knowledge and comprehension are the focus of learning and assessment. In modern education, the ultimate learning goals for students should fall into the more complex categories, like analysis and synthesis, but also important to note that it is just as important to teach a strong foundation of knowledge from which the more complex ideals must rest upon. As stated by Booker, "one can not have a roof without walls to support it" (2007, p. 352).

The use of flash cards in education to help the memorization of facts and basic understanding of concepts is moderately documented, especially in the language and mathematics areas, but less so in music, social sciences, and natural sciences (Din & Wienke, 2001). A study was conducted in which high school chemistry students used flash cards to learn vocabulary and concepts. When compared, the treatment groups had significantly more gain than control groups which suggested that flash cards can be used to help students comprehend chemistry vocabulary (Din & Wienke, 2001).

In another related study, a SMART board was used in combination with flash cards to teach moderately intellectually disabled students how to read grocery store aisle marker words. The researchers determined that the combination of technology and the use of flash cards increased learning outcomes with remembering and comprehending the aisle markers for the students (Mechling, Gast, & Thompson, 2009). While not directly related to mobile phone use, this study showed that combining technology and flash cards can possibly have positive effects for students.

As the above brief literature review indicates, little research has been done to test if mobile phones actually help a student learn the subject content more effectively or not. Most all of the articles seek to find new uses for the mobile technology, how participants

perceive the usefulness of mobile technology, or simply seek the current status of mobile phone use in schools. A seemingly large gap is the lack of classroom data based solely on subject matter performance, not stated by students, but collected empirically by a researcher. This study seeks to add something meaningful to this space in education research.

CHAPTER 3

RESEARCH METHODS

Introduction

"Since the late 1930's the fields of social psychology and education have shown great interest in what has been called action research" (Best & Kahn, 2006, p. 21). Action research is meant primarily to be used locally and not necessarily universally (Best & Kahn, 2006). The advantage of this type of research is the focus on immediate application and the problem of here and now in the local setting. This action research study focuses on only one classroom and any findings found can only be strongly applied to near identical settings and populations. Any more implied generalizations about the findings must be put forth with caution.

Therefore, as a current classroom teacher, action research is the most relevant, appropriate, and convenient type of research to pursue. This study seeks to provide evidence supporting the use or disuse of mobile phones in the classroom for both content and effective outcomes. The outcomes, regardless of the results, will have the potential to improve the local classroom practices.

Setting

The setting of this study is a high school biology classroom in southern California. The room contains two black topped, low laboratory tables that hold sixteen students each. The setting also includes a teacher demonstration table and a teacher desk

with the sole desk top computer in the room. On the table are a variety of helpful technologies including a document reader, combination VCR/ DVD player, and suspended from the ceiling an LCD projector. Facing this table are the 32 student desks that are used for teacher led instruction and lecture. See Appendix G for a picture of the classroom.

The school demographics match closely to the surrounding area. Exactly 87% of the students are Caucasian, 7% are Asian, and remaining 6% is made up of African American, Persian, and Latino groups (WASC, 2006). The families from the surrounding city are mostly affluent and educated and place great emphasis on the value of education as evidenced by the percentage (79%) of parents having 4 year or more college degrees (as reported by parents to the school district and compiled in the district's information data base). Most students come to school equipped with a variety of techno gadgets ranging from iPods and mp3 players to iPads and laptops. Most all students have a mobile phone and many have a smart phone.

Just standing and watching, it is obvious that mobile phone use is pervasive at this school. Students playing games, texting, talking, or any of the other numerous capabilities can be seen constantly during break and lunch. Students are very attached to their phones and express distress when asked to give them up even for an hour.

There are no district wide policies on the use of mobile phones, any stated policies on using such devices is left up to the school sites to determine. The student handbook has only a small passage prohibiting the use of any and all electronic devices during class time and passing periods (Student handbook, 2011, p. 18). Specifically during break time and lunch is its deemed ok to use these devices. As a precaution,

permission was received from the principal to conduct this study with mobile phones in the classroom.

Participants

Four classes of freshmen level biology with 32 students each (ages 14-15) were the potential participants in this study. All have had at least two years of seventh and eighth grade science with most also having science in the upper elementary grades. To be enrolled in freshmen biology at the school, students must also be concurrently enrolled in or have passed Geometry.

To qualify for participation in this study, students and their parents must have given consent to participate, own a mobile phone capable of downloading applications, and fall within the normal grouping score when tested for equivalency. As a precaution and prior to collecting data, a preliminary poll was taken the semester before the study and it showed that 97% of students have a mobile phone and of those, 68% a smart phone. There was no reason to believe those numbers would change significantly for the semester that this study took place. The preliminary survey also indicated an equal number of males to females in the two classes, although not necessarily with those who owned smart phones.

As it turned out, even with these prerequisites in place, two groups of thirty two participants each were formed. These groups demographic distribution were almost identical to the school's demographics with Asian numbers being higher and Hispanic and other sub groups being slightly less in number. Male and female ratios were 55% and 45% respectively.

Data collection and Analysis

This was a mixed method study, qualitative and quantitative data were collected. The quantitative methodology was chosen partly due to the lack of existing studies in this area on the effectiveness of using mobile phones for content learning and qualitative data helps us understand students' perceptions. It would be useful to have data either supporting or refuting the use of phones, but trying to understand the students' perceptions of these possible benefits is also valuable. The research design tool used for this study was the Switching Replication design. In this design, two groups act alternately as either a treatment or control group during two different times.

In the first 2 week session of measurement, the first group received the treatment (the use of mobile phones), and the second group acted as the control (paper flash cards only, so no mobile phone use). In the second 2 week session of measurement the second group received, in turn, the treatment while the first group became the control group. Since each group in the experiment received the treatment at some point, social threats to internal validity such as compensatory rivalry, compensatory equalization, and resentful demoralization, were reasonably eliminated.

Internal threats such as maturation and testing were controlled by having a two group study as any pretesting effects or change in the participants that affect one group can reasonably be assumed to affect the other. Events threatening internal validity were mitigated somewhat by choosing the two groups that have similar daily schedules. For example, the two periods that have the most consistent interruptions, intercom announcements, assemblies, or athletes leaving on a consistent basis (as is frequently the case later in the school day) were omitted form this study. The student population

enrolled at the site is stable with less than twenty students on average changing schools during the school year. It was quite reasonable to expect 99% of the starting participants to remain during the duration of the study and in fact every participant who started the study saw it to its conclusion.

What the Students Actually Did

On the first day of a unit, students went to the computer lab where every student, even the ones not in the study, went to www.studystack.com and created a set of downloadable flash cards for that unit. See Appendix F for a sample image of one of these virtual flash cards. The first unit's topic was ecology and the second was cells. Students who did not participate in the study or who were in the control group typed the electronic flash cards on that topic and printed them out in the computer lab.

Everybody was typing on the computers and not handwriting to minimize modality learning style variables. Students had a minimum list of terms and concepts for which they had to create flashcards, but were encouraged to make more. Two types of cards were made, vocabulary terms (knowledge) and concepts (comprehension). See Appendix H for required terms and concepts.

Every student who eventually would be using their phone in the treatment group also downloaded a free application onto their phones. Depending on the make of the phone, a variety of flash card applications were available. For Droid type phones, Kaka Flash was the best application and for iPhones, the Quizard application was best. Both are free and easy to use for a person who has a basic understanding of the phone's operation. These applications enabled the students to access the stack of electronic flash cards they created on the study stack website via their phone. During each unit, roughly

two weeks each, the last five minutes of each class was given to the students to use their flash cards, electronic or paper. They used them solo and in a quiet setting after the day's lesson plans were finished. The actual use of the flash cards was independent of any lesson going on that day and not tied to any specific learning goal. The students also were encouraged every night to study their flash cards outside of class.

Every student had a provided flash card use log that they filled out at the start of each class on the prior days use of flash cards, electronic or paper. This provided the students' perceived amount of time spent outside of class using the two types of flash cards and enabled the evaluation of equivalent time using them. In class time use was directly observed, recorded by the researcher, and used for qualitative analysis.

Qualitative Portion

To gather the observational and descriptive data on participants, participant observations were made visually and audio recorded during the lessons in which the treatment was being used. The recordings helped ensure accurate accounts of statements made by the participants and to increase internal validity by making sure the same questions were being asked to both groups. Field logs were kept during the study as observational evidence and as a tool to recognize and help reduce observer bias (Bogdan & Biklen, 2007).

After the posttest of each unit, focus group interviews were conducted seeking the students' opinions on how the phones helped or did not help them learn assigned content and their perceptions of using the mobile phones for content learning. These observations, group interviews, and individual interviews formed the basis for a possible triangulation of data and findings. As described below, these group interviews involved

two to four, purposefully picked participants. See Appendix I for interview protocol questions.

Six total participants (two for each score range) participated in the one-on-one in depth interviews as high (85-100%), mid (84-70%), and low (69-0%) scorers on the posttest and were purposely selected to ensure a broad range of experiences. The participants appeared to speak openly and honestly and it was made clear to them that their answers had no effect on their grades and were for research purposes only. The intent of this was to reduce feelings of intimidation or coercion felt by the participants.

Interviews were audio recorded (with participant consent) for future transcribing and data analysis. The recording was done to ensure accurate records of statements and to help internal validity. Any differences in presentation by the teacher or questions asked would be recorded and help reduce bias in the data. In addition, informant feedback and a second reader were also used to increase internal validity. The second reader is the current AP biology teacher at the site (who has taught biology for 13 years), has conducted research for her own thesis, and has a Masters of Education.

With observations, focus group interviews, and individual interviews providing data, themes and trends within that data were looked for and analyzed. Triangulation of the data hopefully showed how the participants truly felt about using the mobile phones for class and in the event that no difference was found between control and treatment groups, why this could be the case (Bogdan & Biklen, 2007).

Observer effects should have been minimized due to the fact that from the view of a student, the role of a researcher is by and large identical to the role of a teacher. The only difference being more questions asked and the use of an audio recorder. Even the

recorder became part of the background quickly and was barely noticed by the students, as illustrated in Bogdan and Biklen (2007).

Quantitative Portion

To test if the mobile phones made a significant difference in test scores, independent samples, two-tailed *t* test were administered on collected posttest data. The mean of the test scores were compared between each treatment and control group pair, once for each 2 week treatment of the study. A two tailed *t* test was used as it was possible the use of the phones could lower test scores in the treatment groups and a one tailed test would not detect that outcome. Equal variance tests were also conducted between groups to evaluate the type of *t* tests to be used when comparing pre and posttest scores.

For analysis considerations, the hypothesis and null hypothesis are as follows: Hypothesis: there will be a significant difference in test scores between the two groups. Null Hypothesis: there will not be a significant difference in test scores between the two groups.

In addition to comparing the treatment and control groups as wholes, the data from the posttests were disaggregated into knowledge and comprehension questions. As the focus is on the flash cards which studies have shown can increase knowledge and comprehension, it would be useful to see if the electronic verses paper flash cards show any difference in those two types of learning. To see the specific questions and how they are classified, see Appendices D and E.

If no significant difference was shown between either treatment group, then one possible conclusion that can be drawn would be that the phones did not make a

significant difference in the test scores and therefore not a significant factor in student learning. Regardless of outcome, the descriptive data did help provide support for reasons why the phones did or did not make a difference in student learning. Observations of the students and their responses were gathered to provide evidence for this possible eventuality.

CHAPTER 4

RESULTS

This study is about testing the effectiveness of small, portable smart phones on student learning. One group of students in a 2 week ecology unit created and used exclusively paper flash cards on ecology. A second group created and used exclusively virtual flash cards that were stored and accessed via their own smart phones. After the 2 week ecology unit, the groups switched roles (treatment group with phones became group with paper flash cards and vice versa) and a second, 2 week unit on cells was taught. Before each unit started a pretest was given to establish group equivalency. After each unit, 30 question posttests were given and analyzed for statistical differences. These 30 questions were taken from the Miller and Levine (2002) biology test bank provided with the biology book and supplement materials.

Each group was created from two combined biology classes with a potential number of 64 students each. However, as each participant needed access to a mobile phone capable of displaying flash cards and parental permission to participate, only 32 students per group participated in this study. There was no attrition as all participants who started this study finished it.

For data analysis of research question one, does using flash cards on mobile phones increase content learning when compared to using flash cards on paper, a quantitative approach was utilized. For research question two, what are students'

perceptions of using the mobile phones for learning content, a qualitative analysis was used. This chapter is therefore split into two main parts addressing these two questions and their analysis.

Quantitative Analysis and Research Question Number One

For the quantitative analyses, data was analyzed via *t* tests and were chosen based on their usefulness in detecting significant differences between the means of two groups of (continuous) data. A two tailed *t* test was used as it was possible the use of the phones could lower test scores in the treatment groups and a one tailed test would not detect that outcome.

T tests are based on an assumption of either equal or unequal variance between samples being compared. As shown in appendix J, all the comparisons tested except for two of the posttest comparisons before the cells unit (the total scores and the comprehensions subscale scores) had equal variance. As this is too large a chance the underlying populations have different variances, I adjusted the *t* test calculations for those two comparisons under the assumption the samples are unequal in variance which is reported in appendix K.

Establishing Group Equivalency

An independent-samples two tailed, *t* test was conducted before each unit to determine whether the treatment and control groups were statistically similar in their knowledge and comprehension about the topics they were about to study. These 10 question pretests were created by the researcher and all questions came from the Biology Standards Practice Test bank published by Prentice Hall (Miller & Levine, 2002) and can be found in appendices B and C. Results are displayed in Table 1 with 32 students in

each sample. The table shows the combined and disaggregated pretest scores for both the ecology and cell units. As shown, the large *P* values indicate that any difference between the two groups is likely due to chance and that it is reasonable to suggest that both groups are equivalent for both units of study.

TABLE 1. Pretest Scores, Two Tailed, Independent Samples *T* Test Analysis

Test Type	*M*	*SD*	*T*=	*P* value
Ecology Pretest Total			$t(62) = -.08$	.938
Phones (a)	6.13	1.50		
Paper (b)	6.16	1.71		
Knowledge			$t(62) = 0.638$	.539
Phones (a)	3.77	.997		
Paper (b)	3.58	1.08		
Comprehension			$t(62) = 0.878$	.425
Phones (a)	2.05	1.25		
Paper (b)	2.23	1.25		
Cell Pretest Total			$t(62) = -.41$	.684
Paper (b)	6.34	1.49		
Phones (a)	6.53	2.12		
Knowledge			$t(62) = 0.004$	.996
Paper (b)	2.82	1.34		
Phones (a)	2.82	1.35		
Comprehension			$t(62) = 0.015$	.896
Paper (b)	3.40	.966		
Phones (a)	3.43	1.13		

Note: $N = 64$, (a) = Group 1, (b) = Group 2

Posttest Results

Does using flash cards on mobile phones increase content learning when compared to using flash cards on paper? To answer this question, I compared student

performance under the two conditions. Independent samples, two tailed *t* tests were used to determine if differences exit in post-unit test scores examining content learning. One test given was after a 2 week ecology unit and another after a 2 week cells unit.

TABLE 2. Ecology Posttest, Two Tailed, Independent Samples *T* Test Analysis

Test Type	*M*	*SD*	*T*=	*P* value
Posttest			$t(62) = 2.02$	.048
Total				
Phones (a)	23.59	3.18		
Paper (b)	21.38	5.34		
Knowledge			$t(62) = 2.69$	.009
Phones (a)	12.0	1.88		
Paper (b)	10.53	2.45		
Comprehension			$t(49) = 1.09$	.282
Phones (a)	11.59	1.93		
Paper (b)	10.84	3.39		

Note: $N = 64$, (a) = Group 1, (b) = Group 2

Ecology Posttest Results

In Table 2, *t* tests are shown for the ecology unit posttests comparing the phone group to the paper group. The total, knowledge, and comprehension subscales are reported. This table shows a statistically significant difference in the total ecology posttest scores for students using flash cards on smart phones ($t = 2.02$, $df = 62$, $p = .048$) compared with paper flash cards and can be concluded that the two groups are significantly different. The mean of the phone group is 23.59 (standard deviation = 3.18) while the mean of the paper group is 21.38 (standard deviation = 5.34).

When scores were disaggregated into knowledge and comprehension subscales, a significant difference in knowledge posttest scores was found for phones ($t = 2.69$, $df =$

62, $p = .009$) when compared to paper flash cards. The mean of the phone group is 12.0 (standard deviation = 1.88) and the mean of the paper group is 10.53 (standard deviation = 2.45). The statistically significant differences in knowledge posttest scores supports electronic flash cards as possibly causing differences in this type of student learning.

The comprehension subscale ecology questions, however, showed no significant difference in the ecology comprehension posttest scores for flash cards on smart phones($t = 1.09$, $df = 62$, $p = .282$) compared to flash cards on paper. The mean of the phone group is 11.59 (standard deviation = 1.93) and the mean of the paper group is 10.84 (standard deviation = 3.39).

Cell Unit Posttest Results

The second posttest was given after a two week cell unit. The previous groups switched roles--those using their phones used paper flash cards, and vice versa. In Table 3, *t* tests are shown for the cell unit posttests comparing the phone group to the paper group. The total, knowledge, and comprehension subscales are reported.

TABLE 3. Cell Unit, Two Tailed, Independent Samples *T* Test Analysis

Test Type	Mean	*SD*	*T*=	*P* value
Posttest			$t(62) = 1.51$	.136
Total				
Phones (b)	25.34	3.72		
Paper (a)	24.06	3.03		
Knowledge			$t(62) = -2.62$	.011
Phones (b)	13.31	1.71		
Paper (a)	12.16	1.82		
Comprehension			$t(62) = -0.22$	.824
Phones (b)	12.03	2.42		
Paper (a)	11.91	2.05		

Notes: $N = 64$, (a) = Group 1, (b) = Group 2

This table shows in the cell unit, no significant difference in the total posttest scores for students using flash cards on smart phones ($t = 1.51$, $df = 62$, $p = .136$) compared with paper flash cards and can be concluded that the two groups are not significantly different. The mean of the phone group is 25.34 (standard deviation = 3.72) while the mean of the paper group is 24.06 (standard deviation = 3.03).

The knowledge subscale shows a significant difference in posttest scores found for phone flash cards ($t = -2.62$, $df = 62$, $p = .011$) when compared to paper flash cards. The mean of the phone group is 13.31 (standard deviation = 1.71) and the mean of the paper group is 12.16 (standard deviation = 1.82). These statistically significant differences in knowledge posttest scores support electronic flash cards as possibly causing differences in knowledge type learning.

The cell unit comprehension subscale questions, however, showed no significant difference for flash cards on smart phones ($t = -.22$, $df = 62$, $p = .824$) compared to flash cards on paper. The mean of the phone group is 12.03 (standard deviation = 2.42) and the mean of the paper group is 11.91 (standard deviation = 2.05).

The p values for total and comprehension question subscales exceed the alpha of .05 leading to the conclusion that the differences could be from random chance and not due to any effect by the treatment. The knowledge sub group though did have a t value greater than the t critical and a p value below .05, supporting the conclusion that the treatment may have made a significant difference in the knowledge posttest scores. It should be noted that the subscales are only 15 questions each and the calculated means between groups are close to only a one question difference. In light of this, the total

combined 30 question *t* tests probably have greater impact when interpreting their effects on student learning overall.

Comparing Self Reported Flash Card Use Outside of Class

Each day of the study participants were asked to fill in a flash card use log estimating how many minutes they used the flash cards, of either type, the day before. I grouped the data into three categories, according to the average number of minutes per day reported by each student. I felt this gave me a better idea on how much time overall the students spent studying flash cards outside of class and was more helpful than another *t* test. In addition, since the students are not likely to remember the exact number of minutes they spent using flash cards the day before (practically, were talking about a difference measured in tens of seconds), analyzing the reported minutes as three categories of data rather than tiny amounts of minutes, probably comes closer to an accurate portrayal of what they did. The average number of minutes the students reported was not real helpful as differences were as small as 20 seconds and that level of recall from a day before was not deemed reliable.

See Table 4 for self reported average number of minutes spent using flash cards outside of class. Both treatment groups reported using the electronic flash cards on the phones for increased time versus the paper flash card groups. The number of users reporting zero minutes of use went down when using the phones when compared to themselves across both units of study and compared to the paper group within the same unit of study. The number of users reporting an average of 4 or more minutes a day with the phones also went up when compared to the other group with paper flash cards for both units of study.

Number of minutes using flash cards in class is not reported as all groups for both units of study used them for equal amounts of time. The amount of time given each day for both units was 5 minutes at the end of class. All participants used their flash cards, electronic or paper, alone for the allotted time.

TABLE 4. Number of Participants Self Reporting Average Number of Minutes Per Day Using Flash Cards Outside of Class

Sub Groups	Ecology Unit		Cell Unit	
	Group a Phones	Group b no phones	Group a no phones	Group b Phones
Zero minutes reported	3	6	10	5
One to 4 minutes reported	21	20	14	17
Greater than 4 minutes reported	7	5	7	8

Qualitative Analysis and Research Question Number Two

What are students' perceptions of using the mobile phones for learning content? To explore this research question, I made participant observations during class and conducted focus group and individual interviews throughout the study. I stopped interviewing when I felt a saturation point was reached and nothing new was being learned. While analyzing the data, patterns, repetitions, and themes were looked for. The following section discusses how I arrived at these conclusions.

The following themes were found within the triangulated data:

1. Students were enthusiastic about using mobile phones over paper flash cards,

2. Having flash cards on a phone is more convenient than paper flash cards because students carry their phones almost everywhere, and

3. Using flash cards on a phone was no more distracting than a phone would normally be.

Coding

Coding is a method of assigning a response or a piece of information to a category so that it can be more easily analyzed or entered into a computer program (Best & Khan, 2006). Initially, closed coding categories developed by others and found in Bogdan and Biklin (2007) were used. During data analysis of participant observations, codes found in Bogdan and Biklen (2006), were used to denote setting, activity, emotion, distraction, methods, and strategy. Additional examples created by the researcher included, perspectives held by students, focus, perceived learning, and flash card use. When participants were observed making decisions about which flash cards to make and then prompted for the reason, the strategy code was assigned. The category, perspectives held by students, appeared frequently as they spoke at great lengths about how they see their own phones as useful to them. The method category was used when a participant would infrequently question their usefulness or contribution to the research aspect of the phone use.

As analysis continued, a number of open codes were created after conversations with the participants and are a direct reflection of what they said or did. For example, any observations or comments made by the participants concerning their motivation or enthusiasm for using the mobile phones was coded under emotion and considered an effect from the phone use. Other codes such as distraction, off topic, phones helpful,

flash card use, phone use, and activity were used and themes emerged from the observer data.

Any time participants were observed using their phones for reasons other than the task at hand, the distraction or off topic codes were applied. The phones helpful code was used whenever participants indicated either through actions or comments, that they found the phones helpful in their study of the material. The activity code was applied when a consistent event happened frequently which included the flash card use time at the end of each period and any repeating actions the participants employed.

Interview analysis included codes such as emotion, mobile, convenient, flash card use, study, more effective, no effect, distraction, and efficient. Emotion was coded anytime a student responded with how they felt about a particular topic and the distraction code anytime the phones were mentioned as a distraction greater than a no phone condition. Mobile was applied anytime a participant indicated a benefit with phones or paper flash cards due to their mobile and easy to carry nature. This was a frequent code which ended up leading to convenient and efficient codes being created with these three eventually becoming a major theme and finding in this paper. A tally of each code was kept with observer data, group interview data, and individual interview data, and codes that appeared in all three groups became the three major findings detailed below.

Inter Rater Reliability

After the qualitative data was analyzed and coding categories were created and used to separate the data into findings, a colleague was brought in to code the raw data a second time to help establish reliability in the findings. This colleague has been teaching

biology for 13 years at the same school and is currently the AP Biology teacher. She has also written a thesis on education and earned a master in education. Both open and closed codes were discussed and under which conditions which codes had been assigned. After she analyzed and coded the data, we compared what we found. She found many of the same codes in the data as I did, especially with two of the major findings, enthusiasm and convenience. The third finding, the idea that phones are not a significant distraction, she found to be less prominent than the other two, but did agree that as a minor finding it was still valid. This process was valuable in that I felt greater confidence in what I thought the data was saying. The following sections discuss the major conclusions I gleaned from the qualitative data analysis.

Increased Enthusiasm for using Cell Phones

Initially the students liked having the phones out and accessible to them during class. The interest among them was high and motivation to use the phones was readily apparent. During the first day of the study, October 18th, in class while making the flash cards female participant one literally jumped up and down with excitement when her flash card application worked. When asked why she was jumping, she said with a big smile, "This is so great. I don't know why, but it just is." This was after she had made the flash cards on the website and successfully downloaded them onto her mobile phone.

While not physically reacting in the same way, participant six asked me the question, "If we do flash cards again, can I always just use this instead of normal ones?" I said yes, but asked why he felt this way and he responded with a chuckle, "I'll probably actually use these." When prodded further he mentioned he has never used paper flash cards, even when forced to make them for a grade, but would likely use them on his

phone. In fact, later after the phone use logs were analyzed, this male participant reported one of the highest number of minutes per day using his phone.

As the class periods went on that day, students started exploring the different functions of the applications for the flash cards. Male participant four was trying out the matching function of the application on his phone where vocabulary words need to be matched to their definitions. As he was showing his friend sitting next to him, I asked him, "How do you like that?" He replied, "This is too cool. It has a built in study guide." I asked him if this would likely mean he would use the flash cards more because it was on his phone and had these additional functions, his response with a nod, "Yeah, likely."

Male participant seven mentioned to a female student after having finished creating his flash cards, "I'm never making real ones again." I quickly walked over to him and asked him to explain what he meant and he said, "This is so much better. Typing them and having them on the phone. I never want to cut out paper ones again." I asked him if he could specify a reason why these were so much better in his opinion and he answered, "Typing, it's so much faster than having to write them all out you know. It would have taken me a couple of hours to write out all these, but, I'm already done." For reference, he typed out over 60 flash cards and downloaded them in under 40 minutes. The efficiency of typed electronic cards is beginning to emerge.

After the first day of the first unit when the students started to use their phones for accessing the flash cards in and out of class, a social element came into play which seemed to me to increase the desirability to use the phones. On the third day, October 20th, some students were observed talking about which pictures to use off a website they had found while utilizing the smart phone's web browsing capabilities. I watched a

group of three of them search and text each other pictures to add to their flash cards. When asked what they were doing, one responded, "Oh, we're just getting this niche (*sic*) pictures to add to the flash cards. John found this one," showing me the picture, "So he sent it to us to use." After asking him if he felt that was an advantage of the phone over paper flash cards, he responded, "Oh yeah, it beats having to draw it, and well, we can help each other make these things [the electronic flash cards] better."

Interviews, group and individual, conducted after the first posttest was done, November 2nd, showed support for increased motivation and enthusiasm for the phones. The students interviewed really seemed to accept the phones as a learning aide and one they wanted to continue using. Female participant eight mentioned during a group interview, "It was useful but it was also cool. Getting to use them in class when normally we don't get to use them in class. It was fun." Female participant nine during a separate interview stated, "It was cool using it with [my friend] and we worked together good. Yes, I like using it." In a solo interview male participant nineteen supported increased enthusiasm with, "This is the only class I've been allowed to use my iPhone in. It's a nice change for once. I like it and would be interested in doing more in class with my phone." In a different solo interview, when asked what she liked the best about using her phone in this manner, female participant ten stated, "It's easy to get into our phones. It's good to use them and the more the better."

While initially excited, some participants seemed to lose that initial excitement for the phones. As the study went on and students came to use the phones a third and fourth week, their enthusiasm seemed wear off a bit. When asked about this during a group interview, three participants indicated that while they still wanted to use their phones for

flash cards, it was less of a big deal than when they started the study. A statement from participant five included, "Yes. It was more fun last time [the ecology unit]. I still like using it because it's easier, but, I don't know, it's fine. I mean I still will use it." and male participant 12 said, "It's like when we watched those videos in Psychology. They were intense and interesting at first, but now I just can't wait till they're over."

At the end of the second unit during a solo interview, having been asked what she thought of the phones after using them for a couple of weeks, female participant 15 stated, "Well, now it's like a part of the background. I just don't think about it [the phone] any more." When asked what he thought about the phones now that we had spent four weeks using them, male participant 20 replied, "I still like using the flash cards on it and I think I will use it more in the future, but it's less, I don't know, exciting maybe. It's apart of the routine now."

Perhaps a novelty effect was in play during the start of the study that diminished as time went on. Possibly the fact that they had to use them for two weeks straight decreased their enthusiasm for using the phones. This may not be a bad thing however, as if the students see their phones used for school purposes as routine, then acceptance of their phones as learning tools may be easier and ultimately better for learning. Unfortunately, no other data collected in this study supports or refutes this novelty idea, and could potentially be a good research question in a future study.

Students Perceive the Phones as Being More Convenient than Paper Flash Cards

Students reported a belief that having flash cards accessible on a mobile phone made them more convenient for student use when compared to paper flash cards. This emerged as a second major theme from primarily the coding of the interviews, both group

and individual, and to a lesser extent participant observations. Open codes such as, more effective, convenient, mobile, and study were applied frequently to interview data and led to this theme.

Male participant two liked the portability and ease of access his phone provided him with a statement during class, "Yeah, it's real useful to have them right there and not have to carry around a stack of cards that I'll probably lose anyway." I asked him why he likely would lose them, and he responded with a shrug, "They're small and get lost easy, so I don't usually bother about it too much." Then female nine added to the conversation, "Even when I put them on the little rings I find ones that have ripped off in my bag. I'd rather put them on my phone too." Both indicated that flash cards on the phone were more efficient for them than paper flash cards. This is consistent with the flash card use logs with reports of greater phone use than paper card use. During a group interview after the ecology posttest, after I asked what their impressions of using the phones were, male participant nine said, "I liked it a lot better, cause like, it's more convenient and faster to use them on your phone cause you still have to write them all out but I type much faster then write and it's just more efficient cause you know you won't lose it."

Another participant during the same interview also expressed a similar view, "Most people take it with them everywhere and so you have it right there. Plus we went to the computer lab and put it in, so then bam, it was right there on my phone." I asked if this made the phones more efficient to use than paper in his opinion and he exclaimed, "Oh, yeah, without a doubt. Computers, typing, not cutting out. This is much more efficient and doesn't waste time."

During a solo interview, male participant five who has dysgraphia, a writing disorder that makes hand writing painful and extremely difficult to read indicated he liked the virtual flash cards primarily due to the typing aspect. "Typing the flash cards into the website and printing was so much better than writing them." I asked, "Because of your hand condition?" and he replied sarcastically, "You know how pretty my writing is, could you imagine me trying to write all these out, much less use them later." He is not exaggerating how un-readable his writing is and for anyone who has these types of issues, perhaps the use of typing and phones can help mitigate some manual dexterity problems.

Additional participants indicated through interviews and observations that hand writing and carrying around a stack of small paper flash cards was less desirable than typing them and having them available via a downloadable application. Male participant one responded at length during an individual interview about this topic. "Yeah, using the phone would be, more modern, to help us study. It applies to what we do everyday better. Not just on paper but with technology. It applies more to our generation with typing into computers rather than writing it on paper, and then cutting them. I'd rather put it in my phone every time." I asked if being more, modern, was important to him and he said, "Yes I think it is. I'm a product of this generation and I've grown up with computers and mobile phones. I mean, I've had a phone since first grade and I've never actually used it for school. Not that I remember anyways." It seems that the technical side of using the phones is what is making them more appealing to some students than a typical paper flash card. I think the appeal of this technology in one simple way is tied to their mobile and easily carried nature.

Also indicated by participants was their perceived willingness to use the virtual cards more frequently, as shown in Table 4, than paper cards. Not only did they believe electronic flash cards were accessible any given time of the day, but the students reported they were more likely to use them instead of paper flash cards, as supported by the flash card use logs. Several participants mentioned using the virtual cards at random moments when they otherwise would be just waiting and doing nothing productive school wise.

For example, while waiting for a dentist appointment one day, female participant three stated, "I used the cards on my phone at the dentist when I was just sitting there waiting." I asked her if that would have happened if she were using paper flash cards instead and she replied, "Maybe, but I probably wouldn't have even thought of using them. It wasn't until I went to play on my phone that I remembered having them in the first place."

Male participant 11 indicated that he used his virtual flash cards frequently when he was waiting for his ride home, but had rarely used paper flash cards in the past during that particular down time. Female participant 12, a dancer, mentioned this after being asked if she found herself using flash cards at odd, random times, "When I was sitting and waiting for my dance song to be up, I sat outside the dance room and did homework. Some of that was using the phone."

Based on these responses I think it is reasonable to attribute some of the flash card use during these small downtimes to the phones themselves and that overall paper flash cards would not have been as accessible or as used. Also indicated by these students was the fact that without the phones having flash cards on them, paper flash card use would

have been likely zero during these times. The availability of the phones is clearly a factor in how the students perceive them and assess the phone's usefulness.

A concept mentioned only by a few participants was the efficiency of typing out flash cards as opposed to writing them out. Since every participant typed, this was not a measurable difference between the groups, but it is worth noting that while only the phone groups found the phones more convenient, some participants liked and found that typing was more time efficient. No participant ever mentioned that hand writing was a preferred flash card creation method.

Phones are not a Distraction

I feared incorporating phones into a lesson could bring off task and distracting behavior. To compound the issue, if students are asked to use their phone for school work outside of class, would the phone prove to be an even greater distraction? Most participants seemed to think that since their phone is an essential part of their lives, it is not any more of a distraction if used for electronic cards than simple paper flash cards would be.

During interviews, most students perceived the phones as not a distraction to them when using the virtual flash cards or at the very least not anymore of a distraction than they already were. A group interview on November 16th yielded statements such as, "It didn't bother me. Why would it?" and "My phone wasn't distracting." When prompted further, female participant two added, "Maybe a distraction, but that would happen whether it was phone or [paper] flash cards anyways. If the phone was just sitting there and it rang I'd answer it." I checked with her by asking, "So you are saying that if your phone rings or you get a text, it doesn't matter if you're on the phone studying or if the

phone is just sitting next to you, you'll still answer it and be distracted from studying anyways?" She responded that is correct and was asked if she had that experience during the duration of the study to which she replied, "I'm sure it did. I get a lot of texts."

In a solo interview, male participant two stated, "The phone is kind of a distraction anyways whether you're on your phone or not." He went on to add, "It was more of a distraction sometimes. I mean, games vs. flash cards, games win out usually. Not always though." I asked him if this made the phones a bad idea to be using then, if he was likely to be distracted by it, but he responded, "Oh no, I like using it. I just don't think it would really matter." I asked what he meant by that and he concluded, "If I'm using it and I want to play a game, I will. If I'm not using it, and I want to play a game, I'll still play the game."

In another group interview, when asked about the phones being a distraction, female participant 17 answered, "I don't think so. Same thing really. I have my phone on me pretty much always. So it's there no matter what." In the same interview, female participant 23 apparently felt the same way as some of the other participants by stating, "No, I don't think the phone would be any more distracting than it already is and it's the same distraction with or without using paper ones. The phone is still near me." Finally, in the last individual interview, male participant 15 stated, "It can be a distraction, but so is anything else that pulls me away from what I'm supposed to be doing." I ask him to clarify what he meant and he continued with, "Well, if I have homework and I'm watching a video on my phone or the TV, that's just the same as texting or playing a game on my phone." It seemed to me, anecdotally, most students saw the phones as a

natural extension of themselves--that they found the phones no more distracting than something as common as their own hands would normally be.

While almost no participants expressed the opinion that their phone would adversely affect their use of flash cards, during class time when the students were supposed to be using the flash cards, phone or paper, I observed on four separate occasions off task phone use. I observed games twice, texting a friend once, and web browsing once. When asked about these activities, two of the four students insisted that they were not being distracted by their phones at that time. Even the two who thought it was a distraction indicated no desire to stop using them. Considering I only caught four instances of this behavior during class over the 24 days they used flash cards in class, there is not enough data to support any findings in this area. Knowing teenagers though, more of this off task behavior was likely happening.

It seems possible to me that while most all participants do not perceive their phones as distracting, certain amounts of distracting behaviors are occurring. If a distracting behavior is defined as something that takes time away from a certain action, such as studying, then maybe the phones could be considered a significant source of distraction, even when the student does not see it as such. Possible consequences of this are discussed in chapter five.

In summary, a statistically significant difference was found for both knowledge level subscales on both unit posttests and that both phone groups scored higher than their paper counter parts. Only the ecology unit had the total posttest questions *t* test showing a significant difference, albeit a slight one. According to observations of students and their interview responses, students were initially enthusiastic to use the phones with the

flash cards, but that enthusiasm waned as time went on. Students overwhelmingly found the phones' greatest benefit in this study to be convenience in accessibility to their flash cards. The phones being distracting was observed in class, but students reported that the phones were not more distracting to them than their phone is normally (in or outside of class). In other words, the phone has a certain level of distraction value, but that value is constant regardless of what the student is doing, and therefore does not detract from its usefulness.

CHAPTER 5

DISCUSSION

Observations and Findings

The results of this study provide preliminary evidence that the use of mobile smart phones in a classroom may help increase content learning in a limited way. Low level learning such as memorization was shown to increase with the phones, but comprehension level learning did not when compared to paper only use. Basoglu & Akdemir (2010) also found similar results when comparing students' scores studying vocabulary materials on mobile phones with paper. Mobile phone users received better test scores than students using identical materials on paper. Therefore, it was concluded that mobile phone use for language learning is more effective than its paper counterparts.

Also to take into consideration is that each subscale, knowledge and comprehension, only consisted of 15 questions each. While it is useful to study different types of learning, in this particular case the total combined scores of 30 questions for each posttest might be more discriminating of student understanding. These 15 question subscales I think turned out to be too small to be truly indicative of any important results. While the difference for knowledge level learning was statistically significant, I do not know if it is practically significant. With only 15 questions and a mean difference of less than two questions, it is hard justify changing entire lesson plans for these results. However, the nice thing about how the flash cards were used in this study does not

necessitate whole lesson plan changes, so maybe it could be worthwhile to try. A study specifically designed to test multiple types of learning with a greater number of testing items could be informative and is a natural extension of this study,

The study stack website made this study possible and includes many useful features and tools that relate to not only using flash cards, but other teaching techniques as well. I think any basic knowledge or recall level learning could benefit from this website and in general the flash cards it helps create.

The participants in this study perceived the phones as a more convenient and efficient way to study key terms and comprehension questions. Overwhelmingly they preferred using the phones instead of paper flash cards and self reported increased use time with the phones over paper. Students can have opportunity to practice anytime and anywhere since they carry their mobile phones almost all the time. A student is far less likely to lose their phone than a small stack of paper also.

These findings are contrary to Suki (2011), who reported students not happy using mobile phones for these purposes, citing small screens and keypads. This difference could be attributed to the different age groups, however, as that study included college age students and this study focused on high school students. A large amount of texting is well documented among American teenagers, on average of 3000 texts per month (Lenhart 2010).

Limitations and Weaknesses

As this study primarily included participants from a narrowly defined socio-economic population, any results can reasonably be applied only to similar populations. Also, only preliminary level memorization and comprehension type learning was

assessed in this study and as such, other types of learning may be influenced differently by mobile phone use. This study was conducted in only a four week time period with each treatment being applied in two week intervals. This short amount of time may result in data that only is valid for short term memory retention as the participants only had to retain the information for two weeks. While initially reporting a significant difference, Suki (2011) found that a delayed test, two months after treatment, showed no significant difference between paper and phone flash cards.

As this study relied on primarily pre selected groups, non-random sampling of the groups was one of the constraints of this study. Further research with randomly chosen samples should be conducted to make findings more general. Creativity in the classroom setting will be required.

One weakness of this study includes the ecology and cells units not being equivalent in difficulty of material to learn. Most of the students have had a significant exposure to lessons involving cells in 7^{th} grade, but much less experience with ecology. Also the fact that there is less of a volume of information to learn in the cell unit when compared to ecology could have made a difference. This might be evidenced by the narrower spread of posttest scores for the cell unit and a wider variance in scores for the ecology unit. For comparison, the ecology unit's total posttest score average is 22.5 with a standard deviation of 4.51 while the cell unit's total posttest average was 24.7 with a standard deviation of 3.4. In the future, a posttest with more than thirty questions and two more equally balanced units of study are recommended.

As with all participant reported data (referring to flash card use logs), there is much room for error and findings must be tentatively accepted in this light. Students may

feel that if they report zero minutes using the flash cards, that they will be penalized in some way. Steps were taken to make them comfortable reporting the truth regardless. A number of students did report zero minutes using flash cards, phone or otherwise, so these results may be more reliable than not. Even if all students inflated their number of minutes using the flash cards outside of class, they may have done so uniformly. If this is the case, then the phone groups still have a higher number of minutes using the flash cards than the paper groups.

As with other quasiexperimental studies, uncontrolled environmental variables exist that could not be mitigated. Student absences, outside class concerns like sports, other classes, and other typical teenager issues for the students could all have impacted their performance in this study. Efforts were made to control for these as much as was feasible given a classroom's constraints. As it turned out, only half of the eligible students, 64 out of 128, ended up apart of this study. Not all had permission from a parent or owned a phone capable of using any of the free flash cards applications available.

Conclusions and Recommendations

Today, mobile phones have already become a routine part of our lives. Decreased cost and increased features of mobile phones have made them popular not only for communication and entertainment, but also for educational purposes. As the mobile phone use becomes more common and application programs running on phones become more appealing, increasing numbers of educators and students alike will start using them in classroom settings (Basoglu & Akdemir, 2010). Figuring out how to use these mobile

phones to maximize learning should be a significant effort of educational and technological research.

Even given some of the drawbacks to allowing phones in the classroom, most all students in the future could benefit from mobile technology. It is up to educators to figure out the best and safest ways to facilitate this. Future studies should continue to empirically test the effects of different uses of mobile phones in lesson plans. These should include new applications, how to minimize off task behavior, and more effective outside class uses for the phones (i.e. video taking, photos, blogging, etc.).

One emergent explanation from this study that could be further explored is this idea about enthusiasm with phones and possibly e-flash cards. Many students felt that it was easier and faster to use electronic flash cards over paper and the convenience of being able to find and copy pictures from the internet to add to e-flash cards was a bonus. Further study into how the internet affects these feelings of increased enthusiasm could be important.

Students seemed to indicate a reduction in enthusiasm as the study went on. Did the novelty of phone use for classroom activities wear off and is this an indicator saying novelty is more important than high tech gadgets in maintaining student enthusiasm? If it is novelty, then new uses of the phone should be introduced throughout a semester keeping the enthusiasm going. Future studies could focus on various new items and techniques in a classroom and compare when and if enthusiasm wanes.

This study only scratched a tiny surface of what these smart phones can do. The simplistic nature of how I used them in class was in a large part due to not wanting to complicate any results I might get. I felt quantifying pictures or video done by students

would have been open to too much interpretation and therefore less meaningful. This study shows just some of the great potential these little pocket computers have in teaching future generations. Teachers should not reject this technology, but learn to harness it and turn it into a force of learning.

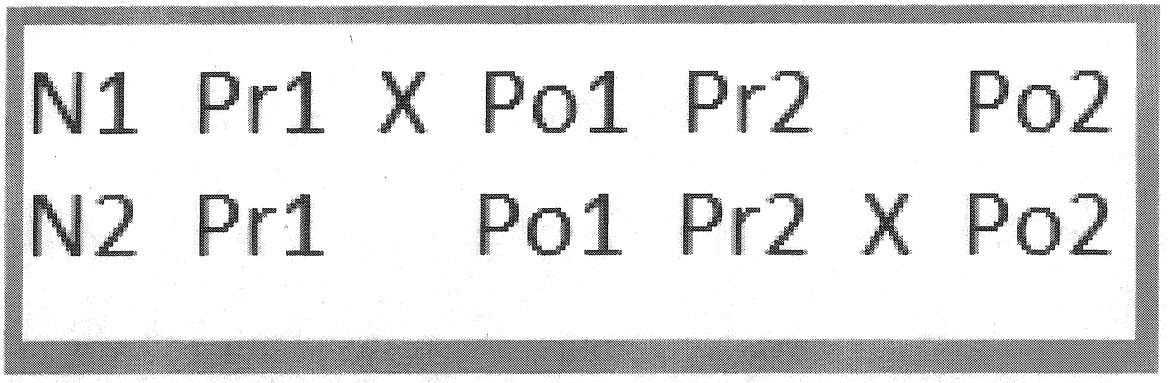
Lastly, after having finished this study, I continued using flash cards and phones in the classroom. Anecdotally, the students after two additional months of utilizing their phones for flash cards continue to support the phones use. In my opinion, any strategy or piece of technology that increases learning or motivation to learn (even if minimal) is a worthwhile effort. I have not statistically analyzed any further test scores, but the students report that they feel like the phones help, and that is good enough for me.

APPENDICES

APPENDIX A

THE SWITCHING REPLICATIONS DESIGN

The Switching Replications Design



N- group
Pr1- 1st unit pretest
Po1: 1st unit posttest
X- treatment with phones
Pr2: 2nd unit pretest
Po2: 2nd unit posttest

APPENDIX B

ECOLOGY UNIT PRETEST

Ecology Unit Pretest

(M) - Comprehension question, **(K)** - Knowledge question

1. **(K)** The branch of biology dealing with interactions among organisms and between organisms and their environment is called
a. economy.
b. modeling.
c. recycling.
d. ecology.

2. **(K)** Plants are
a. producers.
b. consumers.
c. herbivores.
d. omnivores.

3. **(K)** What is the original source of almost all the energy in most ecosystems?
a. carbohydrates
b. sunlight
c. water
d. carbon

4. **(M)** The greenhouse effect is
a. the result of an excess of carbon dioxide in the atmosphere.
b. a natural phenomenon that maintains Earth's temperature range.
c. the result of the differences in the angle of the sun's rays.
d. an unnatural phenomenon that causes heat energy to be radiated back into the atmosphere.

5. **(M)** What does the range of a population tell you that density does not?
a. the number that live in an area
b. the areas inhabited by a population
c. the births per unit area
d. the deaths per unit area

6. **(K)** The movement of organisms into a given area from another area is called
a. immigration.
b. emigration.
c. population shift.
d. carrying capacity.

7. **(K)** An increase in Earth's average temperature from the buildup of carbon dioxide and other gases in the atmosphere is called
a. the greenhouse effect.
b. ozone depletion.
c. global warming.
d. particulate dispersal.

8. **(M)** Which has become the most important source of environmental change on Earth?
a. climate
b. energy
c. human activity
d. conservation biology

9. **(M)** An example of a sustainable-development practice is the use of beneficial insects like ladybugs to
a. harm natural resources.
c. control unwanted pests.

b. pollinate plants.
d. eat unwanted plants.

10. **(M)** Which of the following descriptions about the organization of an ecosystem is correct?
a. Communities make up species, which make up populations.
b. Populations make up species, which make up communities.
c. Species make up communities, which make up populations.
d. Species make up populations, which make up communities.

APPENDIX C

CELL UNIT PRETEST

Cell Unit Pretest

(M) - Comprehension question, **(K)** - Knowledge question.

1. **(M)** Which cell structure contains the cell's genetic material and controls many of the cell's activities?
a. organelle
b. nucleus
c. cell envelope
d. cytoplasm

2. **(M)** Cells fall into two broad categories, depending on whether they
a. have a cell wall.
b. contain genetic material.
c. have a nucleus.
d. contain chloroplasts.

3. **(K)** Which structures carry out cell movement?
a. cytoplasm and ribosomes
b. nucleolus and nucleus
c. microtubules and microfilaments
d. chromosomes

4. **(K)** The thin, flexible barrier around a cell is called the
a. cell membrane.
b. cell wall.
c. cell envelope.
d. cytoplasm.

5. **(M)** Which organelle would you expect to find in plant cells?
a. mitochondrion
b. ribosome
c. chloroplast
d. smooth endoplasmic reticulum

6. **(M)** Which of the following structures serves as the cell's boundary from its environment?
a. mitochondrion
b. cell membrane
c. chloroplast
d. channel proteins

7. **(K)** The diffusion of water across a selectively permeable membrane is called
a. osmotic pressure.
b. osmosis.
c. facilitated diffusion.
d. active transport.

8. **(K)** A group of similar cells that perform a particular function is called a(an)
a. organ.
b. organ system.
c. tissue.
d. division of labor.

9. **(M)** Eukaryotic cells are found in
a. viruses.
b. bacteria.
c. plants and animals.
d. all living organisms.

10. **(K)** The nucleus of a cell is enclosed by

a. nucleolus.
b. chromatin.
c. ribosomes.
d. nuclear envelope.

APPENDIX D

ECOLOGY POSTTEST

Ecology Posttest

(M) - Comprehension question, **(K)** - Knowledge question.

1. **(K)** The combined portions of Earth in which all living things exist is called the
a. biome.
b. community.
c. ecosystem.
d. biosphere.

2. **(K)** An organism that uses energy to produce its own food supply from inorganic compounds is called a(an)
a. heterotroph.
b. consumer.
c. detritivore.
d. autotroph.

3. **(K)** Only 10 percent of the energy stored in an organism can be passed on to the next trophic level. Of the remaining energy, some is used for the organism's life processes, and the rest is
a. used in reproduction.
b. stored as body tissue.
c. stored as fat.
d. eliminated as heat.

4. **(K)** Matter can recycle through the biosphere because
a. matter is passed out of the body as waste.
b. matter is assembled into chemical compounds.
c. biological systems do not use up matter, they transform it.
d. biological systems use only carbon, oxygen, hydrogen, and nitrogen.

5. **(K)** Temperatures on Earth remain within a suitable range for life as we know it because of the
a. unequal heating of Earth's surface.
b. loss of heat to space.
c. radiation of sunlight back into the atmosphere.
d. greenhouse effect.

6. **(K)** The tendency for warm air to rise and cool air to sink results in
a. global wind patterns.
b. ocean upwelling.
c. unequal heat distribution.
d. regional precipitation.

7. **(K)** An organism's niche is
a. the range of physical and biological conditions in which an organism lives and the way in which it uses those conditions.
b. all the physical and biological factors in the organism's environment.
c. the range of temperatures that the organism needs to survive.
d. a full description of the place an organism lives.

8. **(K)** A symbiotic relationship in which both species benefit is
a. commensalism.
c. predation.

b. mutualism.
d. parasitism.

9. **(K)** When organisms move out of the population, this is known as
a. emigration.
c. immigration.
b. abandonment.
d. succession.

10. **(K)** When individuals in a population reproduce at a constant rate, it is called
a. logistic growth.
c. exponential growth.
b. growth density.
d. multiple growth.

11. **(K)** The various growth phases through which most populations go are represented on a(an)
a. logistic growth curve.
c. normal curve.
b. exponential growth curve.
d. population curve.

12. **(K)** Demography is the scientific study of
a. parasitism and disease.
c. human populations.
b. modernized countries.
d. none of the above

13. **(K)** Using renewable resources while ensuring that they are not depleted is a practice called
a. sustainable development.
c. biological magnification.
b. monoculture.
d. subsistence hunting.

14. **(K)** The number of different species in the biosphere is called
a. biodiversity.
c. genetic diversity.
b. ecosystem diversity.
d. species diversity.

15. **(K)** Biodiversity is important to human society because it
a. is a natural resource.
c. provides medicines.
b. provides food and goods.
d. all of the above

16. **(M)** Why are fossil fuels nonrenewable?
a. They require hundreds of millions of years to form.
b. Their ecosystems change forever when they are burned.
c. They are converted to carbon dioxide when they are burned.
d. They exist in a very small supply.

17. **(M)** When erosion and other factors cause soil to lose its ability to hold water and other nutrients and to support plant life, it is called
a. desertification.
c. deforestation.
b. depletion.
d. monoculture.

18. **(M)** What is meant by "a library of genetic information" in reference to biodiversity?
a. The biodiversity of plants and animals is interesting to read about.

b. All living organisms contain genetic information upon which humans can draw for future use.
c. Species provide humans with many useful products to enhance our lives.
d. We have much to admire in the many forms of life that surround us.

19. **(M)** What is happening in a population as it decreases?
a. The birthrate and the death rate remain the same.
b. The death rate becomes lower than the birthrate.
c. The death rate stays the same and the birthrate increases.
d. The death rate becomes higher than the birthrate.

20. **(M)** When the exponential phase of a logistic growth curve of a population ceases,
a. the size of the population drops.
b. the size of the population stays the same.
c. population growth begins to slow down.
d. population growth begins to speed up.

21. **(M)** Which will reduce competition within a species' population?
a. fewer individuals
b. higher birthrate
c. fewer resources
d. higher population density

22. **(M)** If a population grows larger than the carrying capacity of the environment, the
a. death rate may rise.
b. birthrate may rise.
c. death rate must fall.
d. birthrate must fall.

23. **(M)** The loss of heat to space is slowed by
a. radiation entering the atmosphere.
b. atmospheric gases.
c. solar energy.
d. the biosphere.

24. **(M)** The greenhouse effect is
a. the result of an excess of carbon dioxide in the atmosphere.
b. a natural phenomenon that maintains Earth's temperature range.
c. the result of the differences in the angle of the sun's rays.
d. an unnatural phenomenon that causes heat energy to be radiated back into the atmosphere.

25. **(M)** Why does Earth have three main climate zones?
a. Warm air rises at the equator and cold air sinks over the poles causing an unequal distribution of heat over Earth.
b. There are differences in latitude and, thus, the angle of heating from the sun.
c. Continents and other landmasses physically interfere with global heat distribution.
d. The Earth rotates and affects the major ocean currents.

26. **(M)** What is one difference between primary and secondary succession?
a. Primary succession is slow and secondary succession is rapid.

b. Secondary succession begins on soil and primary succession begins on newly exposed surfaces.
c. Primary succession modifies the environment and secondary succession does not.
d. Secondary succession begins with lichens and primary succession begins with trees.

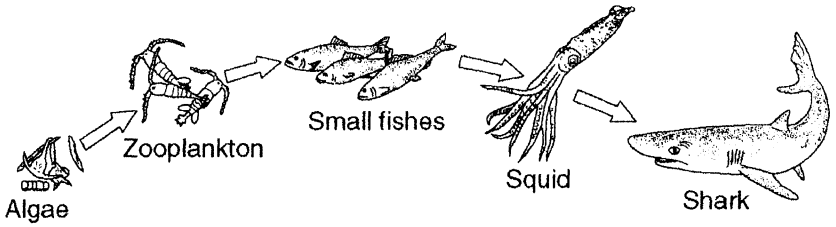


Figure 3–1

27. **(M)** The algae at the beginning of the food chain in Figure 3–1 are
a. consumers.
b. decomposers.
c. producers.
d. heterotrophs.

28. **(M)** Most of the energy available to a consumer trophic level is used by organisms for
a. transfer to the next trophic level.
b. respiration, movement, and reproduction.
c. producing inorganic chemical compounds.
d. performing photosynthesis.

29. **(M)** The movements of energy and nutrients through living systems are different because
a. energy flows in one direction and nutrients recycle.
b. energy is limited in the biosphere and nutrients are always available.
c. nutrients flow in one direction and energy recycles.
d. energy forms chemical compounds and nutrients are lost as heat.

30. **(M)** What can happen after a lake receives a large input of a limiting nutrient?
a. An algal bloom occurs.
b. Algae begin to die and decomposers take over.
c. Nitrogen compounds are recycled.
d. The concentration of oxygen drops below the necessary level.

APPENDIX E

CELL UNIT POSTTEST

Cell Unit Posttest

(M) - Comprehension question, **(K)** - Knowledge question.

1. **(K)** Who was one of the first people to identify and see cork cells?
a. Anton van Leeuwenhoek
b. Robert Hooke
c. Matthias Schleiden
d. Rudolf Virchow

2. **(K)** Electron microscopes can reveal details
a. 100 times larger than those visible in light microscopes.
b. the same size as those visible in light microscopes.
c. 100 times smaller than those visible in light microscopes.
d. 1000 times smaller than those visible in light microscopes.

3. **(K)** Which of the following contain a nucleus?
a. prokaryotes
b. bacteria
c. eukaryotes
d. organelles

4. **(K)** Which of the following is a function of the nucleus?
a. stores DNA
b. controls most of the cell's processes
c. contains the information needed to make proteins
d. all of the above

5. **(K)** Which of the following structures is found in the cytoplasm?
a. nucleolus
b. ribosome
c. chromatin
d. cell wall

6. **(K)** Which organelle converts the chemical energy stored in food into compounds that are more convenient for the cell to use?
a. chloroplast
b. Golgi apparatus
c. endoplasmic reticulum
d. mitochondrion

7. **(K)** Which organelle would you expect to find in plant cells but not animal cells?
a. mitochondrion
b. ribosome
c. chloroplast
d. smooth endoplasmic reticulum

8. **(K)** Which of the following is a function of the cytoskeleton?
a. helps a cell keep its shape
b. contains DNA
c. surrounds the cell
d. helps make proteins

9. **(K)** The main function of the cell wall is to
a. support and protect the cell.
b. store DNA.
c. direct the activities of the cell.
d. help the cell move.

10. **(K)** Unlike the cell membrane, the cell wall is
a. found in all organisms.
b. composed of a lipid bilayer.
c. a flexible barrier.
d. usually made of tough fibers.

11. **(K)** Which of the following structures serves as the cell's boundary from its environment?
a. mitochondrion
b. cell membrane
c. chloroplast
d. channel proteins

12. **(K)** Diffusion is the movement of molecules from
a. an area of low concentration to an area of high concentration.
b. an area of high concentration to an area of low concentration.
c. an area of equilibrium to an area of high concentration.
d. all of the above

13. **(K)** The diffusion of water across a selectively permeable membrane is called
a. osmotic pressure.
b. osmosis.
c. facilitated diffusion.
d. active transport.

14. **(K)** Which term refers to cells having different jobs in an organism?
a. multicellular
b. cell specialization
c. levels of organization
d. unicellular

15. **(K)** A group of similar cells that perform a particular function is called a(an)
a. organ.
b. organ system.
c. tissue.
d. division of labor.

16. **(M)** Which of the following is NOT a principle of the cell theory?
a. Cells are the basic units of life.
b. All living things are made of cells.
c. Very few cells reproduce.
d. All cells are produced by existing cells.

17. **(M)** Eukaryotes usually contain
a. a nucleus.
b. specialized organelles.
c. genetic material.
d. all of the above

18. **(M)** Which of the following organisms are prokaryotes?
a. plants
b. animals
c. bacteria
d. all of the above

19. **(M)** Which of the following is NOT found in the nucleus?
a. cytoplasm
c. chromatin

b. nucleolus
d. DNA

20. **(M)** Which organelle breaks down food into molecules the cell can use?
a. Golgi apparatus
b. lysosome
c. endoplasmic reticulum
d. mitochondrion

21. **(M)** Which structure makes proteins using coded instructions that come from the nucleus?
a. Golgi apparatus
b. mitochondrion
c. vacuole
d. ribosome

22. **(M)** Which of the following is a function of the cell membrane?
a. breaks down lipids, carbohydrates, and proteins from foods
b. stores water, salt, proteins, and carbohydrates
c. keeps the cell wall in place
d. regulates which materials enter and leave the cell

23. **(M)** The cell membrane contains channels and pumps that help move materials from one side to the other. What are these channels and pumps made of?
a. carbohydrates
b. lipids
c. bilipids
d. proteins

24. **(M)** Diffusion occurs because
a. molecules constantly move and collide with each other.
b. the concentration of a solution is never the same throughout a solution.
c. the concentration of a solution is always the same throughout a solution.
d. molecules never move or collide with each other.

25. **(M)** When the concentration of molecules on both sides of a membrane is the same, the molecules will
a. move across the membrane to the outside of the cell.
b. stop moving across the membrane.
c. move across the membrane in both directions.
d. move across the membrane to the inside of the cell.

26. **(M)** Which means of particle transport requires input of energy from the cell?
a. diffusion
b. osmosis
c. facilitated diffusion
d. active transport

27. **(M)** An animal cell that is surrounded by fresh water will burst because the osmotic pressure causes
a. water to move into the cell.
b. water to move out of the cell.
c. solutes to move into the cell.
d. solutes to move out of the cell.

28. **(M)** The cells of multicellular organisms are

a. smaller than those of unicellular organisms.
b. simpler than those of unicellular organisms.
c. specialized to perform different tasks.
d. not dependent on one another.

29. **(M)** All of the following are types of tissues EXCEPT
a. muscle.
b. connective.
c. digestive.
d. nerve.

30. **(M)** An organ system is a group of organs that
a. are made up of similar cells.
b. are made up of similar tissues.
c. work together to perform a specific function.
d. work together to perform all the functions in a multicellular organism.

APPENDIX F

EXAMPLE OF FLASH CARDS MADE IN STUDY

Example of Knowledge (K) Flash Cards Made by the Study Stack Website

Front	*Back*
What is the basic structural and functional unit of life	Cells

Front	*Back*
What is the function of mitochondria?	Creates energy in the form of ATP to power the cell.

Examples of Comprehension (M) Flash Cards Made by the Study Stack Website

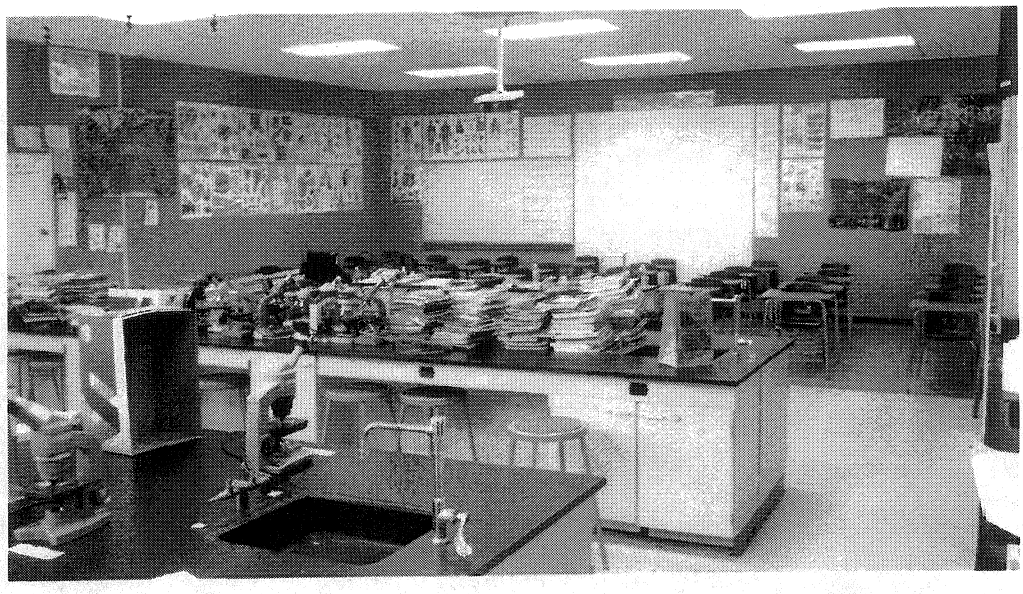
Front	*Back*
Explain why having greater numbers of organisms in a food webs makes it more stable.	The greater number decreases the chance of extinctions and provides greater food sources...

Front	*Back*
Explain why the green house effect is crucial to life on Earth.	Maintaining a stable, long term temperature on the planet makes life possible...

APPENDIX G

PICTURE OF CLASSROOM THAT STUDY OCCURS

Picture of Classroom that Study Occurs



APPENDIX H

REQUIRED FLASH CARD TERMS AND CONCEPTS

Required Flash Card Terms and Concepts

Cell Unit: cell, cell theory, prokaryotes, eukaryotes, nuclear envelope, chromatin, ribosomes, Endoplasmic Reticulum, nucleus, Golgi apparatus, lysosomes, cell Membrane, cell wall, centriole, chlorophyll, chloroplast, chromosome, cytoplasm, mitochondria, nucleolus, vacuole, cytoskeleton

Ecology Unit: ecology, biosphere, autotroph, heterotroph, food web, biomass, biogeochemical cycles, greenhouse effect, climate, biome, succession, biotic, abiotic, exponential growth, logistic growth, carrying capacity, limiting factor, renewable resource, sustainable development, biodiversity.

APPENDIX I

INTERVIEW PROTOCOL QUESTIONS

Interview Protocol Questions

1. What are your impressions on using the phone for a classroom related assignment?
2. Do you think that the phone helped you learn the material better than not using it? If so why, and if not why not?
3. Did you use the virtual flash cards outside of class? How often?
4. Did you use the paper flash cards outside of class? How often?
5. Did using the phone make the lesson any more fun for you? If so why, and if not why not?
6. Do you think the phone was a distraction that possibly made learning more difficult? If so why?
7. Would using the phones more in the future during class as a part of a lesson be something you would look forward to? i.e. would it make the class more enjoyable?

APPENDIX J

T TESTS WITH EQUAL VARIANCE

Ecology Pretest Analysis

	Total		Knowledge		Comprehension	
	Phones	Paper	Phones	Paper	Phones	Paper
StDev	1.497	1.706	.914	.942	1.091	1.164
Variance	2.242	2.910	.835	.887	1.190	1.354
Ratio of StDev	0.878		.970		0.937	
Ratio of Variance	0.770		.941		0.879	

Note: *N*=32, Alpha = .05

Ecology Pretest Total Scores

Method	*DF*1	*DF*2	Statistic	*P*-Value
F Test (normal)	31	31	0.77	0.472
Levene's Test (any continuous)	1	62	0.14	0.712

Ecology Pretest Knowledge Scores

Method	*DF*1	*DF*2	Statistic	*P*-Value
F Test (normal)	31	31	0.94	0.866
Levene's Test (any continuous)	1	62	0.16	0.694

Ecology Pretest Comprehension Scores

Method	*DF*1	*DF*2	Statistic	*P*-Value
F Test (normal)	31	31	0.88	0.721
Levene's Test (any continuous)	1	62	0.64	0.427

Ecology Posttest Knowledge Subscale

	Knowledge	
	Phones	Paper
StDev	1.884	2.449
Variance	3.548	5.999
Ratio of StDev	0.769	
Ratio of Variance	0.591	

Note: N=32, *Alpha* = .05

Method	*DF* Phones	*DF* Paper	Statistic	*P*-Value
F Test (normal)	31	31	0.59	0.149
Levene's Test (any continuous)	1	62	2.04	0.158

APPENDIX K

T Tests with Unequal Variance

T Test with Unequal Variance, Ecology Posttest, Total and Comprehension Subscale

	Total		Comprehension	
	Phones	Paper	Phones	Paper
StDev	3.181	5.345	1.932	3.390
Variance	10.12	28.565	3.733	11.491
Ratio of StDev	0..595		0.570	
Ratio of Variance	0..354		0.325	

Note: N=32, *Alpha* = .05

Ecology Posttest, Total

Method	*DF* Phones	*DF* Paper	Statistic	*P*-Value
F Test (normal)	31	31	0.35	0.005
Levene's Test (any continuous)	1	62	3.83	0.055

Ecology Posttest, Comprehension

Method	*DF* Phones	*DF* Paper	Statistic	*P*-Value
F Test (normal)	31	31	0.32	0.002
Levene's Test (any continuous)	1	62	4.39	0.040

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