COMPARISON OF LEARNING PERFORMANCE BETWEEN STUDENTS WHO DO AND STUDENTS WHO DO NOT USE MOBILE TECHNOLOGY-BASED ACTIVITIES

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This study examined if using mobile technology-based activities would increase student performance in biological science courses. The study compared two groups of students in lectures and labs. Each group had about 20 students. The mobile group had mobile technology-based activities and the non-mobile group received conventional instruction. The mobile group used links to the website, or a QR Code to access the activities. The non-mobile group had handouts and worksheets over the same content. The research methodology for this study was mixed method. The study was a quasi-experimental design that used instruction method as the independent variable between two groups. The study used formative and summative assessment to compare the performance of the mobile group and non-mobile group in lecture and lab. The student in the mobile group had statistically significantly higher lab exam scores than students in the non-mobile group. Additionally, Students were surveyed about their performance expectancy and effort expectancy using mobile technology for learning, and they were asked about their self-management of learning. Analysis indicated that both groups had similar performance and effort expectancy using mobile technology for learning, but the two groups differed on self-management of learning responses to the survey. Focus groups from the mobile group and the non-mobile group were interviewed about issues related to benefits and challenges encountered learning with mobile technology-based activities.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGEMENTS</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
</tbody>
</table>

## CHAPTER 1 INTRODUCTION

1.1 Introduction to Mobile Learning ................................................................. 1
1.2 Statement of the Problem ........................................................................... 2
1.3 Purpose of the Study ................................................................................... 3
1.4 Definition of Terms .................................................................................... 4
1.5 Limitations .................................................................................................. 4
1.6 Overview of Dissertation ............................................................................ 5

## CHAPTER 2 LITERATURE REVIEW

2.1 Introduction ................................................................................................. 6
2.2 Historical Background of Mobile Learning .................................................. 6
2.2.1 Reason for Mobile Learning ..................................................................... 12
2.2.2 Usage, Perceptions, Acceptance, and Expectancy ................................... 19
2.2.3 QR Codes for Mobile Learning ................................................................. 21
2.3 Theoretical Framework Based on Activity Theory ....................................... 26
2.4 Potential Issues With Mobile Learning ....................................................... 30
2.5 Research About Mobile Learning ................................................................. 36
2.5.1 Improved Performance ............................................................................ 36
2.5.2 Motivation ................................................................................................ 39
2.5.3 Student Engagement .............................................................................. 43
2.5.4 Convenience and Easy Access for Learning .......................................... 45
2.6 Exemplary Educational Objectives and Student Learning Outcomes ........... 48
2.7 Pilot Study .................................................................................................. 49

## CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction ................................................................................................... 53
3.2 Research Design, Procedure, and Participants ............................................. 53
5.3.4 Combined Lecture and Lab Exam Results................................................. 114
5.3.5 Survey Results ....................................................................................... 114
5.3.6 Focus Group Interview Results ............................................................. 116
5.3.7 Pedagogy and Problem-based Learning .............................................. 120
5.3.8 Summary of Results ........................................................................... 122

5.4 Implications ............................................................................................ 126
5.5 Recommendations .................................................................................. 131
5.6 Conclusions ........................................................................................... 131

APPENDICES ........................................................................................................ 133

REFERENCES ....................................................................................................... 205
LIST OF TABLES

Table 3.1  Activities for Lecture ................................................................................................... 58
Table 3.2  List of Lab Activities ................................................................................................... 59
Table 4.1  Lecture Exam Comparison Between Instructional Method for Descriptive Statistics 65
Table 4.2  ANOVA Comparison Between Instructional Method and Lecture Exams ............... 66
Table 4.3  Descriptive Statistics for Lecture Quizzes Comparison Between Instructional Method ....................................................................................................................................................... 67
Table 4.4  Lecture Quizzes Comparison Between Instructional Method ANOVA ...................... 68
Table 4.5  Lab Exam Comparison Between Instructional Method for Descriptive Statistics ..... 69
Table 4.6  ANOVA Comparison Between Instructional Method and Lab Exams ..................... 69
Table 4.7  Lab Quizzes Comparison Between Instructional Method for Descriptive Statistics... 70
Table 4.8  Lab Quizzes Comparison Between Instructional Method ANOVA ............................ 71
Table 4.9  Combined Exam Averages and Instructional Method Descriptive Statistics .............. 71
Table 4.10 Combined Exams Averages and Instructional Method ANOVA .............................. 72
Table 4.11 Bivariate Correlation of the Student Survey Responses and Exams ..................... 74
Table 4.12 Analysis of Focus Group Participants ................................................................. 75
Table 4.13 Grouped Survey Response Compared to Instructional Method by ANOVA ............ 76
Table 4.14 SL Survey Responses Compared to Instructional Method by ANOVA ................. 77
Table 4.15 Survey Data Analysis of Focus Group Participants .............................................. 86
Table 4.16 Themes of Disadvantages ......................................................................................... 87
Table 4.17 Themes of Depends ................................................................................................. 87
Table 4.18 Themes of Benefits ................................................................................................ 87
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Model of activity theory.</td>
<td>28</td>
</tr>
<tr>
<td>4.1</td>
<td>Combined groups lecture exam average by SL</td>
<td>78</td>
</tr>
<tr>
<td>4.2</td>
<td>Non-mobile group lecture exam average by SL</td>
<td>78</td>
</tr>
<tr>
<td>4.3</td>
<td>Mobile group lecture exam average by SL</td>
<td>79</td>
</tr>
<tr>
<td>4.4</td>
<td>Combined groups lab exams average by SL</td>
<td>79</td>
</tr>
<tr>
<td>4.5</td>
<td>Non-mobile group lab exam average by SL</td>
<td>80</td>
</tr>
<tr>
<td>4.6</td>
<td>Mobile group lab exam average by S</td>
<td>80</td>
</tr>
<tr>
<td>4.7</td>
<td>Combined exams averaged by SL</td>
<td>81</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

1.1 Introduction to Mobile Learning

Mobile learning was a multidisciplinary field of study that used mobile devices for communication, collaboration, and instruction. According to the International Telecommunication Union, in 2011, mobile or cellular phone service could have potentially reached about 90% of the world’s population with second generation or 2G mobile services. At that time, about 87% of the world population (6 billion people) had access to mobile technology. Second generation or 2G mobile service had enough wireless spectrums to allow people to talk and send text messages. The use of text messaging for communication reached eight trillion text messages in 2011 (International Telecommunication Union Fact and Figures, 2011). The development of third generation or 3G mobile service provided millions of people with high-speed access to the internet. Third generation or 3G mobile service reached 45% of the world’s population, and 3G technology has helped to get millions of people online. In 2011, about one-third of people in the world were online, and about 45% of these people were below 25 years old (International Telecommunication Union Fact and Figures, 2011). Mobile technology has provided educational institutions with tools to reach millions of potential students. These students could access their courses via 2G or 3G mobile service. Furthermore, educational institutions need to design and develop engaging content for mobile technology. Content for mobile technology should be researched to determine the methods that result in positive student learning outcomes. A combination of engaging content and mobile technology could potentially interest millions of students (Global Mobile Statistics, 2012; International Telecommunication Union Fact and Figures, 2011).
In 2012 the number of connected mobile devices, the vast majority of which were mobile phones, surpassed the world’s population for the first time in history. Yet despite their ubiquity and the unique types of learning they support, these technologies were often prohibited or ignored in formal systems of education (UNESCO Policy Guidelines for Mobile Learning, 2012). According to Chen-Chung & Milrad (2010), educators and researchers were becoming aware of how mobile technologies used in daily life could be used for learning. They discussed how these devices along with sound pedagogy could change learning from merely productive knowledge acquisition into an engaging activity. Moreover, the accelerated global adoption of smartphones provided an opportunity for making mobile technology an integral component of learning.

1.2 Statement of the Problem

A critical analysis of mobile learning projects revealed design space and gaps in the research (Frohberg, Göth, & Schwabe, 2009). One of the problems with mobile learning was the lack of research on how mobile technology based instructional design could affect student performance in science. For example, the lack of research on mobile learning based instruction in the biology is a problem. Additional research needs to be conducted to fill in the gaps in mobile learning. This is especially true for the biological laboratory where very little research has been conducted. As the gaps are filled, mobile learning in the classroom and lab may move from being prohibited or ignored to an effective method of instruction in formal systems of education. This research works to fill a small part of that gap by researching the effectiveness of mobile technology-based activities on student performance in a biological science course.
1.3 Purpose of the Study

This study was a comparison of learning performance between the students who use and the students who do not use mobile technology-based activities in a biological science course. The instructional method used two versions of the classroom and laboratory content. The two groups were divided into one group of students (mobile group) who used the mobile technology-based activities, and one group of student (non-mobile group) that did not use the mobile technology-based activities. To access the content, The mobile group students were either provided a link to the website, or provided a QR Code. The type of mobile device that the students needed only had to access the internet. The non-mobile group students were provided with traditional handouts and worksheets of the same content. Research questions that the study sought to answer include the following:

- Did the mobile technology increase students’ scores on quizzes and summative exams in lectures? If so, how and why?

- Did the mobile technology increase students’ scores on quizzes and summative exams in labs? If so, how and why?

- What benefits and challenges did students encounter in their learning during the mobile technology-based activities?

This was a quasi-experimental study between two non-randomly selected groups. The students enrolled themselves into the courses in the study. The study compared two different classes of students in the same non-science major biology course by the same instructor. The study used pretest and posttest to determine any differences in the students in the two groups. The experimental (mobile group) received mobile technology-based instruction, and the control (non-mobile group) received traditional instruction and handouts. Students in the mobile group were told that having a mobile device for the course was recommended. Students in non-mobile group were prohibited from using their mobile device in the lecture or laboratory.
1.4 Definition of Terms

- Mobile devices: devices such as smartphones, cell phones, PDAs, netbooks, laptops, tablets, iPods, iPads, e-readers such as the Nook, Kindle Fire, and other devices that are portable and connect to the internet (Franklin, 2011).

- Mobile learning: formal and informal learning that occurs using mobile devices (Traxler, 2007); this type of learning can occur anywhere or anytime (Franklin, 2011).

- Quick Response Code (QR Code): The QR Code is a two-dimensional type of barcode that can be scanned by mobile devices to deliver content to the student (Susono and Shimomura, 2006).

1.5 Limitations

The principal limitation of this study was that the author/researcher was the primary designer of the mobile technology-based instruction, and the author taught the course in the study. Although the multiple roles that the author/researcher played in the study may help enrich the qualitative and descriptive aspects of the study, they may also affect the objectivity of the study. In addition, the students in the two groups, mobile group and non-mobile group were not randomly selected for the study. Instead, the students enrolled themselves in the two classes, which were used by the researcher to assess the learning effect of mobile technology-based activities. Pretests were conducted to determine the possible differences of the students’ general abilities between the two classes and results showed no significant difference. Still, other factors rather than mobile technology may affect the learning performance difference between students of the two classes.
1.6 Overview of Dissertation

Chapter 1 was an introduction to the research of this dissertation. Chapter 2 examines the relevant literature related to mobile learning. Chapter 3 discusses the research methods of the study. Chapter 4 presents the results of the study. Chapter 5 discusses the findings, implications, recommendations, and conclusions.
2.1 Introduction

This chapter examines the relevant literature related to mobile learning. This literature review is divided into several sections: 1) a historical background of the development of mobile technology; 2) reasons for using mobile learning; 3) an examination of the research related to the usage, perceptions, acceptance, and expectancy of mobile learning; 4) the usage of QR Codes for mobile learning; 5) Activity theory which was used as the theoretical framework for mobile learning activities; 6) potential issues related to mobile learning; 7) research designed to compare student learning outcomes in mobile learning; and 8) discussion of a pilot study that used mobile technology-based activities.

2.2 Historical Background of Mobile Learning

Mobile learning started in the late 1990’s and early 2000’s. Mobile learning developed from the academic movement to provide one computer to each student. The one computer per student or 1:1 computing was part of the discussion about the use of technology for improving academic achievement, and then 1:1 computing gradually moved to handheld devices for each student to use for learning (Norris and Soloway, 2004). Owston and Wideman (2001) researched different computer to student ratios 1:1, 1:2, 1:4, and control group with no computers. The lower computer to student ratio was the most effective for learning. The ratio of one computer to four students had higher classroom noise level than lower computer to student ratios. The ratio one computer to four students was not observed to be working at a productive level. According to these researchers, the students that had a computer were engaged in learning, and they were
able to do higher-level analysis, synthesis, and evaluation (Owston and Wideman, 2001).

One-to-one computing did not live up to its expectations for student achievement. Providing each student with a laptop computer has not resulted in significant gains in achievement (Norris & Soloway, 2010). The cost for all of this computer technology was in the billions of dollars. According to Norris and Soloway (2011a), the reason for this lack of achievement was the following: same textbooks, curriculum, and pedagogy. The classroom computer work was substituted for pencil and paper. The U.S. needs to prepare students to work in the 21st century, and the students need 21st century tools to learn how to work both independently and in a team. (Norris & Soloway, 2011b). According to Norris and Soloway (2012), the U.S. can use mobile technologies to transform the classroom into a place where learn-by-doing is practiced, or continue what the U.S. has done in the past by integrating mobile technology into the existing direct-instruction curriculum.

In the past, the use of computer technology to improve academic performance was inhibited by several factors (Norris, Soloway, and Sullivan, 2002). These researchers used survey data from over 4000 teachers to determine the factors that inhibited students from using computer technology. The most common factor cited for a lack of achievement related to computers was limited access to computers in the classroom. For example, the survey data indicated that 68% of these teachers had either no access, seldom (less than once a week), or once a week access to a computer lab. According to Norris et al. (2002), the lack of access was because of the high cost of computers. The average price for a laptop computer was a $1000. This prevented many educational institutions from trying to reduce the computer per student ratio nearer to 1:1.

The lack of educational software was another factor that inhibited computer technology
from improving academic performance (Norris, Hossain, & Soloway, 2011). Without educational software on the computers, there were little to no activities for the student to do on the computers. The classroom computers only came with Microsoft Office and a web browser. The teachers were taught how to use the Microsoft Office software on their computer, but they did not have professional development on how to change the curriculum to take advantage of this technology. According to Norris et al. (2011), the lack of professional development and educational software resulted in instructors creating pen and paper activities to be completed on the computer. Students used the computers to write papers and look up information, or the computers were used to supplement paper and pencil lessons. The educational software that did exist was expensive, and the high cost of buying engaging educational software would prevent students from having the software on their computer (Norris et al., 2011).

The argument was made that institutions should move from desktop and laptop computers to handheld devices (Soloway, Norris, Blumenfeld, Fishman, Krajcik, & Marx, 2001). The two main reasons for switching to handheld devices were decreased cost and increased access. Institutions could not afford the $1000 laptop for each student, but they would be able to buy several handheld devices at $150. Without adequate technology access for every student, technology will not change the effect on student achievement (Soloway et al., 2001).

Handheld devices cost less than laptop computers, and the devices can provide suitable computer function for student learning (Norris & Soloway, 2004). The argument being made for a change to handheld-centric classrooms was that classrooms with one to one ratio of devices to students could use the technology 100 percent of the time. This change would be gradual to allow teachers to use their existing lesson and add activities that require students to use their handheld devices (Norris & Soloway, 2004). Over time, the number of classroom activities with
handheld devices would gradually increase to a level that provided sufficient time on task for the technology to effect learning and achievement. Additionally, they argued that technology pervades nearly every part of our lives, and students need to be fully trained to use this technology effectively for the workplace (Norris & Soloway, 2004).

In 2004, Norris and Soloway put forth the idea of a handheld-centric classroom. They predicted that handheld devices would provide students with access to resources and information in a timely manner (Norris et al., 2011). They proposed a classroom that would have students with instant access to technology 100% of the time, and this additional access could increase time on task and lead to increased learning and achievement. This type of access to technology would require a significant change in the curriculum. Instead of students only using technology for supplemental instruction for a few minutes each day, the handheld device would be their primary learning tool (Norris et al., 2011). The change to a handheld-centric classroom did not happen because of several factors. One factor was that institutions would have to change their teaching methods. This change would cause an additional need to change the assessments related to new curriculum (Norris et al., 2011). An added factor was the lack of classroom management software for handheld devices. Instructors needed classroom management software to prevent them from being overwhelmed by the documents and materials created by the students. Another factor that prevented the development of a handheld-centric classroom was the device cost. Many institutions did not have the funding to purchase devices for their students (Norris et al., 2011). An additional cost factor was the need for wireless network infrastructure to access the internet. Institutions that wanted to change from computers to wireless devices needed expensive wireless networks to connect the devices to the internet (Franklin, 2011). Moreover, they need technical support for classrooms with mobile devices, and a network infrastructure that supports
these devices for instruction. This factor requires information technology (IT) personal trained to support mobile devices and instructors. These previous factors limited the institutions from providing classrooms with handheld or mobile devices, but this has not stopped both students and instructors from bring their own devices to class (Franklin, 2011).

Students expectations have changed and they now expect to have wireless internet access everywhere for their personal mobile devices (Readying Your Campus for Mobile Learning and BYOD, 2012). This expectation of BYOD will increase demands on the existing wireless infrastructure at institutions. Institutions will need to develop policies for student using the wireless infrastructure, and they will need both short-term and long-term plans to maintain the wireless infrastructure. The policies will set limits for approved content and usage time. In the short-term, institutions need adequate wireless access for instruction. Long-term plans will require the institutions to develop adequate funding to support the changes that occur as more devices are connected to the wireless network (Readying Your Campus for Mobile Learning and BYOD, 2012).

High-speed wireless internet access was free to everyone at coffee shops like Starbucks (Starbucks Corporation, 2013). Students expect to walk into a business or college campus and get free wireless internet access. This trend of free Wi-Fi has spread to airports, restaurants, department stores, and many other locations (BBB, 2013). Students want to bring their own device with them everywhere to access the internet and check Facebook. Facebook was the top used app across all mobile systems (One-to-One 2.0 Building on the “Bring Your Own Device” (BYOD) Revolution, 2012). As more students get access to smartphones or other mobile devices, they will expect to be able to bring them to class and everywhere else. This combination of BYOD and demand for wireless internet access will continue to grow as more students, faculty,
and staff bring mobile devices to campus. As of January 2013, about 55 percent of United States mobile phones were smartphones and as other phones are replaced by smartphones, the demand for wireless internet access will grow (Comscore Corporation, 2013).

The BYOD movement has developed from the lower cost of mobile technology, and the expectation of being able to connect to the internet at all times. Students are supportive of BYOD policies because their mobile device was an extension of themselves (Readying Your Campus for Mobile Learning and BYOD, 2012). As the technology moved from heavy laptops and personal digital assistants (PDAs) with a limited number of functions to lightweight multi-functional mobile devices that could get on the internet, people wanted to bring their own device with them all the time. As a result, these devices have become ubiquitous in society, and institutions must plan for BYOD (Readying Your Campus for Mobile Learning and BYOD, 2012).

These mobile technologies were banned in most of the educational institutions in the United States, but the need to provide students with emergency communications has started to change these restrictive policies (Norris & Soloway, 2011c). New BYOD policies have allowed more technology into the classroom. To take advantage of increased student access to mobile technology, instructors need curriculum that has engaging and motivating activities for students. Moreover, instructors and institutions will need to address the various types of mobile devices that will not have the same functionality (Norris & Soloway, 2011c).

In summary, the historical change in technology over the last ten to twenty years has shaped mobile learning. Institutions will face the greatest changes from BYOD and new demands placed on the wireless infrastructure. For example, institutions must shift their focus from providing enough computers for students to providing wireless access for instruction. As
students bring their own technology with them to class, the policies that banned mobile technology will be changed. Because of these changes, instructors will need to be provided tools and training to take advantage of the mobile technology entering their classrooms.

2.2.1 Reason for Mobile Learning

The major reasons for using mobile technology for learning include: ubiquitous in work and education, BYOD policies, embedded tools (camera), communication, apps and student engagement. A reason for using mobile learning was that mobile technology has become ubiquitous in our world (Traxler, 2007). Many people carry their mobile devices habitually without thinking about it. Like one’s car keys and wallet, one’s mobile device has become a normal part of their daily items. This access to mobile technology has altered the nature of work. Traxler (2007) described how workers must now be part of the mobile workforce and the connected society. Workers and students can get information delivered to their mobile device anytime they need it. According to Traxler (2007), finding information rather than knowing it has become part of mobile learning. As mobile technology has become ubiquitous in the environment, the tools that many of these mobile devices contain make them practical for learning.

Currently there is a movement in the business sector away from providing a mobile device to an employee and toward a BYOD workplace (Hildreth, 2011). Mobile service companies provide support for other businesses as they change to BYOD. This support includes device management, user support, security enforcement, and accountability for personal and business use. According to Hildreth (2011), the shift in the workplace has already begun to move toward only mobile business communications. Businesses have been moving away from
According to Hinks (2012), mobile technology for businesses was still in the early days of development. Many businesses were starting to understand the potential of mobile technology for customer engagement. Mobile technology has changed the way customers want information. Businesses have started informing customers about their products and services with apps on smartphones. Customers wanted to be able to access information from any device and from any location. Hinks (2012) also stated that businesses today must adapt to these changes in the world. Failure to adapt will result in a business being replaced by competition. Hinks (2012) gave some practical examples of customer interactions using mobile technology. These examples included buying tickets to the movies, paying bills with online banking, and buying coffee at Starbucks (Hinks, 2012). These were examples of how businesses have already started to learn how to respond to the expectations of their customers. These customers are the students entering educational institutions expecting the same service using their mobile technology. To begin to meet these expectations, educational institutions could make practical policy changes that allowed students to connect their own devices to the wireless network.

The BYOD policy allowed students to use their own personal technology on the wireless network (One-to-One 2.0 Building on the “Bring Your Own Device” (BYOD) Revolution, 2012). Many educational institutional have changed to support BYOD as a practical way to save financial resources on the cost of textbooks (One-to-One 2.0 Building on the “Bring Your Own Device” (BYOD) Revolution, 2012). If institutions changed their policies to allow students to bring their own devices to campus, this could reduce the cost of technology on the institution. The institution would no longer need to provide every student computer access. The combination
of BYOD policies and the use of mobile technologies by students in their personal life could reduce the time and cost of providing the training required for mobile learning (One-to-One 2.0 Building on the “Bring Your Own Device” (BYOD) Revolution, 2012). New features such as texting, cameras, and computer applications have turned mobile technologies into mini-computers, which further facilitated its integration into teaching and learning (One-to-One 2.0 Building on the “Bring Your Own Device” (BYOD) Revolution, 2012).

According to Norris et al. (2011), the reason for using mobile technology was the need to teach 21st century skills to students using the tools of the 21st century and not using the tools based on the 18th century pencil-and-paper. Many of the mobile devices have embedded tools that can be used for learning. For example, students can use their digital cameras to take images of objects in class for discussion. The mobility of this technology was one of the advantages for learning. An example of mobility occurred when students used their smartphones to take pictures of the different plant structures they were studying in class. These students took the content they were learning about at school out into their home environments and created new content to share with their class. The mobility of the technology allowed the students to use it outside of the classroom. According to Norris et al. (2011), the students in their study already valued the use of mobile technology outside of the classroom. Thomasson (2002) practical reason for the digital camera was documenting laboratory experiments. During the experimental procedure, students could take images or video with their device to share or study later for the exam. Digital images could be taken in the field to document the specific organism that was collected for lab analysis (Thomasson, 2002). Another example of out of the class usage for digital cameras would be documenting an unknown fungus around a tree, and then using a camera or smartphone to take an image of it before collecting a part of the organism for lab analysis.
Another place students could take advantage of digital images was in the laboratory. Digital camera adapters for microscopes were used to document the cellular and spore structures for identification of fungus. The use of digital images for specimens was recommended for learning biology (Thomasson, 2002). Digital cameras and image software provided more tools for teaching in laboratories that uses microscopes (Mills, Kelly, and Jones, 2001). Prior to digital cameras students had to hand-draw the image in their microscope for later study. According to Mills et al. (2001), students were able to use their digital camera to take images from their microscopes, so they could study the images at home. The increase in the number of images also resulted in an increase in the class discussions about the different images the students had taken. Digital images were easier to use for instruction because a class could focus on the computer screen with the image. Digital images were easier to use than taking turns looking into a microscope to view a particular slide. These images were used on the laboratory practical exams. Using images instead of microscopes was easier because the students would knock the microscopes out of focus moving from scope to scope. Problems with the microscopes required the instructor to stop the exam to refocus the microscopes. The images benefited student learning, and the images could be used to change the way teaching laboratories demonstrate microscopic activities (Mills et al., 2001).

Healthcare students can also take advantage of digital images of laboratory specimens. According to Foster (2010), images were powerful educational tools that had replaced the traditional laboratory methods of teaching and learning histology and pathology. Digital cameras were used to take images of microscopic specimens in both histology and pathology. The digital images of specimens replaced the boxes of glass slides. Images could be standardized for a convenient learning tool, whereas the microscope slides had significant variability in quality.
Student could conveniently access images on their mobile devices for studying. Students used the images of the microscope specimens to verify the actual microscope specimens for positive identification. The images were easily shared for collaboration between students or other healthcare professionals (Foster, 2010).

Students have used their mobile device for communication, collaboration, and entertainment in their daily lives (Franklin, 2011). These same features have been used to make mobile devices powerful tools for learning. In lecture, students used their mobile devices to quickly fact check their instructor, or they could find someone who completed the class assignments last semester for help. They could also copy the information or assignments directly with their mobile device. During class, students were using their devices to communicate and collaborate by sending text messages and discussing on social networks. However, teachers have used the texting abilities of smartphones for engaging activities in class with website called polleverywhere.com (Franklin, 2011). This website allowed students with a mobile device connected to the internet, to text answers to questions in class. The activity engaged all of the class at once by having them texting their answers to their instructor’s computer (Franklin, 2011).

Day and Kumar (2010) used SMS text messaging to create individualized and interactive game experiences in a large class of business students. The game was called the “Beer Game.” The Beer Game was a competitive supply chain game that students played by SMS or text messaging. Sending text messages to the student’s mobile device created new opportunities for teacher and student interaction. The students received individualized feedback on their mobile device. The game helped to engage students in learning by shifting their focus to strategies and concepts instead of calculations. According to Day and Kumar (2010), the majority of the
students reported they liked the game. Although, a few of the students reported that slow text messaging service effected their participation. The researchers reported that the reason for using mobile technology was student engagement. The text messaging game helped the students understand the information faster, and texting allowed almost instant communication between students and instructor (Day & Kumar, 2010).

Computer applications for mobile devices are called apps. Apps can be used for communication, entertainment, learning, and social networking. Franklin (2011) documented that apps on mobile devices allowed both the students and the instructors to communicate and share information. Software companies for education and organization have designed various apps. The apps were used for learning a language, math, find locations, and connecting to other students. In 2011, the costs of most apps were much less, than the cost of most of the software used on desktops or laptops. For example, the cost of some of the apps ranges from .99 cents to a few dollars. The lower cost of the apps available to support learning was a powerful reason for using mobile technology (Franklin, 2011).

According to the Wilson, 2011, there were hundreds of educational apps available for the iPhone or iPad. For example, the iTunes U app included traditional course lectures, notes, practice questions, and other supplemental material for learning. According to Wilson (2011), this app allowed instructors to send course information and podcast of lectures to students. Students could access their course information through the iTunes U app (Apple Corporation, 2013). According to Wilson (2011), the simple and intuitive design of several apps for the iPhone and iPad made them highly engaging for students. These apps were available in various topics such as geography, math, language, reading, and science. For instance, the world atlas app provided students with high definition maps of the world. With this app, the touch screen on the
iPad allowed students to change from place to place with a simple touch (Wilson, 2011). In another example, introductory math students used an app to learn how to count numbers, and more advanced math students used apps that provided calculus assistance. Other apps were designed to help students with visual and hearing impairments. These apps provided audio and text versions of the content to assist the impaired. Closed captioning was available for several movies and podcast on the iPhone and iPad. Organizational, scheduling, and calendar apps were used to increase individual student organization skills. For example, the calendar app allowed students to set automatic reminders. The reminders could tell them to work on their class assignments before the due date (Wilson, 2011).

Hudson (2010) researched the impact that cultural diversity had on desired mobile reference services and library resources. A survey asked students how likely they were to access librarians for live research assistance on their mobile device. These volunteers were asked to participate when they used the library computer terminals at a state college in Pennsylvania (Hudson, 2010). White male and African American female students reported a higher likelihood and desire to access a librarian from their mobile device. Additionally, the survey asked if they had a smartphone, and 95% of the students reported they had a smartphone. The research implications from the data supported the idea that mobile devices could be used to engage diverse student populations, and the research showed how culture effects student engagement with reference librarians.

Spikol and Milrad (2008) researched an outdoor game for mobile devices that required physical motion, problem solving, inquiry, and collaboration. According to Spikol and Milrad, their mobile game was designed to explore new learning methods and engaging activities for students. The game was a mobile treasure hunt. During the game, the student’s mobile device
provided them the tools necessary for learning. The outcomes of the activities provided information for designing more outside learning activities that connected to the classroom activities. Additionally, they argued that whether educators like it or not students will bring their mobile devices to the classroom (Spikol & Milrad, 2008).

In summary, there were many reasons to use mobile technology for learning. The practical reason for mobile technology comes from the simple fact that mobile technology is everywhere in the environment. Students will need to know how to use mobile technology in the workplace. Mobile devices have embedded features and apps that make them practical for learning. Mobile technologies and games could be used to engage diverse student populations in their learning.

2.2.2 Usage, Perceptions, Acceptance, and Expectancy

In addition to student engagement and the practical reasons for using mobile technologies, other studies have examined usage, perceptions, acceptance, and expectancy of mobile learning. Wang, Wiesemes, and Gibbons (2012) studied mobile device usage and perceptions of six mature doctoral nursing students in support of their research activities. In their study, the students reported their usages of the devices given to them for the study. Wang et al. (2012) found that the students used their mobile devices for email, data storage, file management, audio recording notes, viewing information, and editing presentations. These students engaged with the mobile devices for their personal learning, and they each had different levels of usage. The students’ levels of usage were affected by their familiarities with the devices, by wireless connectivity, and by instructions on how to use the devices. Some of the students reported difficulty learning the functions of the device. For example, one of the students
reported being afraid of accidentally deleting her files because she was not familiar with using the mobile device. Technical issues required one of the students to work with the IT staff to try to repair her device. To address these issues related to mobile devices, the researchers recommended technical training and support as the students start learning how to use the technology. Despite some technical difficulties, the students used their mobile devices to record audio and document ideas for their work. Students develop different levels of expertise depending on their interest, needs, and the limitations of the technology. Wang et al. (2012) suggested that an ideal mobile device for learning should be something small enough to be easily carried at all times, intuitive to use, and connected to the internet at all times.

Demirbilek (2010) surveyed 113 instructors from eight European countries to study their perceptions of using mobile technologies for teaching. According to the survey, 76% of the instructors expressed an interest in using mobile devices in their activities. More than half of those surveyed used electronic games for teaching. About seven percent of the European educators in the study used mobile devices for educational games. When the instructors were asked about a preference between asynchronous or synchronous games on the mobile devices, half of the instructors preferred the synchronous games. Open source computer coded games were preferred by 33% of the instructors, because they wanted the ability to modify the games in the future. Demirbilek (2010) discussed the need for institutions to study the attitudes and perceptions of the faculty before curriculum planners in adult educational institutions consider integration of mobile games. Additionally, the study confirmed that adult educators were willing to take advantage of the capabilities of mobile devices to meet their needs and the need of their students (Demirbilek, 2010).

A study by Wang, Wu, and Wang (2009) surveyed 330 participants to determine their
acceptance of mobile learning. The research looked at the participant’s intention to use mobile learning. This study was based on the unified theory of acceptance and use of technology (UTAUT). The participants were Taiwanese adults from 20 to 60 years old (with 61.2% men). The participants were asked about their perceptions and intentions of using mobile technology for learning. The survey indicated there were some differences in the perceptions of mobile learning between those who were over 30 and those who were under 30 years of age. The younger people had a more positive perception of mobile learning than those who were older (Wang et al., 2009). Additionally, the researchers found that performance expectancy, effort expectancy, social influence, perceived playfulness, and self-management of learning were all determinants of the survey participant’s behavioral intention to use mobile learning (Wang et al., 2009).

Moran, Hawkes, and Gayar (2010) studied student acceptance of mobile devices (tablet computers) by modification of the UTAUT. They found that implementation of a tablet computer into multiple subject areas had a higher probability of success, if institutions provided the required training on how to develop engaging mobile activities. This study did not find gender bias for the effort expectancy variables. The range of ages for traditional college students did not provide enough population segments to study differences. Experience with computers significantly effected acceptance of technology (Moran et al., 2010).

2.2.3 QR Codes for Mobile Learning

This section of the literature review contains information about the usage of QR Codes by the public and recommendations for using QR Codes for education. Research that supported the effectiveness of QR Codes for learning included formative assessments, periodic table of
elements, interactive literature project, and outdoor activities. The Quick Response (QR) Code has been used with mobile technology for product information for almost twenty years (Susono & Shimomura, 2006). They described the QR Code as a two-dimensional symbol developed by Denso Corporation of Japan in 1994. The QR Code was similar to a barcode used on products, but the QR Code can contained more information. A barcode contained about 20 digits, while the QR Code contained around 7000 characters.

A study by Susono and Shimomura (2006) used mobile devices and QR codes for a formative class assessment. According to Susomo and Shimomura (2006), the QR Codes made it easier to find and view webpages on the mobile device because a student could scan the QR Code instead of typing the long web addresses into the mobile phones. To access a QR Code with a mobile device, you need a QR Code reader or scanner app. The camera embedded on mobile devices was used to scan the QR Code. The scanned QR Code opened the information on the mobile device. The information from a QR Code varied from free texts, phone numbers, SMS, contact information, to websites. Susono and Shimomura (2006) described how they created a QR Code for the students to obtain class information. Instructors can use the website www.the-qrcode-generator.com to make free QR Codes. Students scan a QR Code made by the instructor with a QR Code Reader to access the information. The QR Code Reader will store the scanned information in the QR Reader’s digital history. The student can later access the information stored in the QR Code Reader’s history to study, or they can complete and submit an assignment using their mobile device (Susono & Shimomura, 2006).

A survey about QR Codes was conducted by marketing and communications agency called MGH Corporation (MGH's QR Code Usage and Interest Survey, 2011). According to the survey of 415 smartphones users, about 63% indicated they had seen a QR Code. They reported
seeing QR Codes on products, magazine, coupons and other items. About half of the participants said they had actually used a QR Code. The participants also indicated that they used the QR Code to get coupons, information about a product, access video, make a purchase, and interact on social media. The primary reason for scanning a QR Code, according to the survey, was to get a coupon or discount (MGH's QR Code Usage and Interest Survey, 2011).

Robertson and Green (2012) reported on the use of QR Codes, and they made several recommendations for the use of QR Codes. Instructors needed to make sure their QR Codes provided a benefit to their students. For example, they discussed how an English instructor created a QR Code that connected the student to extra vocabulary help online. They recommended that instructors create simple QR Codes before attempting to design custom QR Codes. Some of the QR Code readers and generators worked better than other QR Code readers, so they recommended that instructors should try out several to determine which ones work the best. They recommended that instructors remember to make sure the students were connected to the internet. A lack of internet connectivity can stop students from being able to download the content from the QR Codes. Another recommendation was to printout the QR Codes to give to students, and the instructor should keep a copy for later use (Robertson & Green, 2012).

Crompton, LaFrance, and van 't Hooft (2012) provided several suggestions and examples of how instructors could turn traditional lessons into engaging activities. In one example, QR Codes were used for labeling the parts of the skeleton. The QR Code provided the student information about the parts and function of the bones, or the students could scan the QR Code to access videos about the skeleton. QR Codes could be used to provide students with scaffolding to support their learning. For example, the instructor could create a QR Code that linked to a tutorial to show students how to work math problems. In another example, they described a
World War II Memorial QR Code scavenger hunt. As the participants reached different part of the World War II Memorial, they scanned a QR Code that linked them to radio broadcast and webpages about the war. According to Crompton et al. (2012), mobile devices and QR Codes had been used to link traditional lessons to engaging digital information.

During a formative assessment, students scanned the QR Codes with their mobile devices to complete the activity (Susono & Shimomura, 2006). Then students completed a survey for class improvement by scanning the QR Code with their mobile device. The researchers found that the students liked using their mobile devices, but they did not like using their data plan that cost them money. Some of the students had older mobile phones that could not scan the QR Code. Each student was using their own mobile device, and the different devices had some variation in the screen displays (Susono & Shimomura, 2006).

Bonifácio (2012) described how the entire periodic table of elements was changed to QR Codes. Each of the elements had a separate QR Code that linked to a video about the elements. Students scanned the QR Codes and downloaded the video. The videos required a good internet connection because it could take 30 minutes to download. The QR Codes also linked to the Royal Chemistry Society podcasts about the elements. The podcasts provided information about the periodic table of elements. Blind, visually impaired, and seeing students could use their mobile device to listen to the podcast about the chemical elements. QR Codes and mobile device could be used to link students to content (Bonifácio, 2012).

In a British literature class, the instructor created engaging activity by having the students make their own QR codes for their literature project (Walden, 2011). The QR Codes were attached to their project to help share information with other students. The students used the QR Codes to cite their sources for their paper. Then the instructor used a smartphone to scan the QR
Codes on the project. This project changed from being just read to interactive, because the students had to scan, learn, and discuss with each other (Walden, 2011).

Radio frequency identification (RFID) and QR Codes were used to identify trees in a course about natural vegetation and ecological diversity of plants (Osawa, Noda, Tsukagoshi, Noma, Ando, Shibuya, & Kondo, 2007). The students were all undergraduate students majoring in horticulture, biology, or education. The 21 students were divided into four groups. Each group had a personal computer (PC) with an RFID reader and a mobile phone with a QR Code reader. The trees were labeled with RFID tags and QR Codes. Students scanned the RFID tags and QR Code on the trees. Then the students downloaded the information about the trees on their mobile device or the PC. After the fieldwork identifying the trees, the student answered questions about their experience in the field. The results from the students indicated they were motivated to learn using this technology (Osawa et al., 2007).

After the experiment, students commented on the RFID and QR Codes (Osawa et al., 2007). One of the comments was about the difficulty trying to type on the PC while standing. Another commented that detection of the RFID was easier than finding the QR Code because the group only had to be in the general area around the radio tag. Some of the students had issues with seeing the PC. For example, the PC was difficult to see when the sunlight was brighter than the display. The size of the device was also a factor because the PC was heavier than the mobile phone. Some of the students liked the mobile device because it was easier to handle than the larger PC for outdoor fieldwork. Another student commented that it was easier to scan a QR Code with the mobile phone than using a PC in the field. Some of the students had an issue with the QR Codes because they were blown around by the wind. Some of the students commented the small mobile phone screen size. These students had trouble seeing the images on their mobile
phones. According to Osawa et al. (2007), the students enjoyed using their system for learning about the natural vegetation, and the students indicated that the small lighter mobile device system for identification was better.

In summary, the QR Codes have been considered as an effective tool for education. Research that supported the effectiveness of QR Codes for learning included students completing a formative assessment in class using their mobile device. Students created their own QR Codes for their projects. Research also indicated that mobile technology and QR Codes were effective at making outdoor activities for tree identification.

2.3 Theoretical Framework Based on Activity Theory

Activity theory was the theoretical framework used to evaluate the mobile technology-based activities in this dissertation. Activity theory has been presented as a philosophical framework for studying different forms of human learning at both individual and social levels (Jonassen and Land, 2000). Activity theory provided a way for analyzing learning processes and outcomes for designing instruction. Rather than focusing on knowledge, it focused on the activities in which people were engaged. It focused on the nature of the tools they used in those activities, the social and contextual relationships among the collaborators in those activities, the goals and intentions of those activities, and the objects or outcomes of those activities (Jonassen and Land, 2000). According to Engeström and Glăveanu (2012), activity theory was from psychology with roots in Eastern Europe. Activity theory was connected to Engestrom’s theory of expansive learning that built on Vygotsky. Vygotsky (1978) stressed the role of social interaction in cognitive development. According to Jonassen and Land (2000), activity theory was a useful framework for understanding the totality of human work and praxis.
Activity theory could draw attention to important factors considered during the analysis of teaching and learning activities (Mwanza & Engeström, 2005). The activity theory was based on a cultural–historical activity system, and the theory was mediated by tools that both constrained and supported students in their goals (Liaw, Hatala, & Huang, 2010).

Activity theory has been widely used to understand organizations (Scanlon & Issroff, 2005). The way to understand human behavior was situated within a social context that influenced actions. These actions were mediated by rules of the community and the division of labor within the community. The rules and community influenced the way in which people behaved. Scanlon and Issroff (2005) used activity theory to understand the ways in which learning technologies affected students’ experiences (see Figure 2.1).

Student activity was the unit of analysis that examined the ways in which teaching and learning activities were shaped by experiences. Additionally, teaching and learning activities were shaped by relationships, mediators, and social–cultural influences from the environment (Mwanza & Engeström, 2005). According to Mwanza & Engeström (2005), the activity triangle model represented an outline of the various components of an activity system into a unified whole. From the concept of the activity theory, Engeström analyzed the activities through an expanded framework that showed the interactions between tool-mediated activities, cultural rules, community, and division of labor (Liaw et al., 2010). According to Jonassen and Land (2000), the subjects of any activity were the individual or group of actors engaged in the activity. All activities were object-oriented. Objects of activity systems were artifacts that were produced by the system. Whether physical, mental, or symbolic, these products were acted on by the subject. The transformation of the object into the outcome represented the purpose or intention of the activity. As individuals engaged in activity systems, they were changed by those systems.
Tools were the means that actors (subject) used for acting on the object. They could be anything used in the transformation process (physical, abstract, or mental). The tools altered the activity and the activity altered the tools (Jonassen & Land, 2000). The division of labor referred to a division of tasks between cooperating members of the community. The rules referred to the explicit regulations, laws, policies, and conventions that affect the activity. As well as the implicit social norms, standards, and relationships among members of the community that affect the activity. Rules inherently guided the actions or activities acceptable to the community, so the signs, symbols, tools, models, and methods that the community used mediated the process (Jonassen & Land, 2000). The community consisted of the individuals and groups that focused at least some of their effort on the object. The community negotiated and mediated the rules that described how the community functioned and supported the activities (Jonassen & Land, 2000).

*Figure 2.1.* Model of activity theory. This model of activity theory is for the use of technology in higher education. Adapted Scanlon and Issroff (2005).
According to Scanlon and Issroff (2005), activity theory could be applied to settings that involved the use of technology in higher education. Activity theory helped in examining how different outcomes influenced the interaction between features of the learning situation. For example, activity theory provided a comprehensive understanding of the features that affected the effectiveness of learning technologies. An example of a learning technology that was developed with activity theory was a mobile learning system by Liaw et al. (2010).

According to Liaw et al. (2010), the purpose of the research was to develop a mobile learning system based on activity theory that benefited the student’s ability to find and share information. After the implementation of a mobile learning system, researchers investigated the student’s acceptance of the system. Acceptance of the mobile learning system was determined by a seven-point Likert scale survey. Statistical analysis showed that the students had a positive attitude toward the system. Students used the mobile learning system to create their own knowledge based on prior experience and mental concepts (Liaw et al., 2010).

Sharples, Taylor, Vavvoula (2005) modified activity theory into a new theory of mobile learning. Sharples et al. (2005) separated activity theory into two layers. The semiotic layer described learning as a system in which a student’s actions toward an object were mediated by cultural tools and signs. The technology layer described learning as an engagement with technology. Sharples et al. (2005) changed the rules, community, and division of labor into control, context, and communication respectively.

Not all researchers agreed to the proposed changes of the activity theory for mobile learning by Sharples et al. (2005). For instance, Sharples et al. (2005) changed the rules to control. Then Sharples et al. (2005) divided control into two layers. The technological layer described as human-computer interaction and the semiotic layer described as social rules. This
framework was seen as lacking a connection between the semiotic layer for social rules and semiotic layer for community. In addition, Sharples et al. (2005) divided the object into two layers. The technological layer was described as access to information, and the semiotic layer was described as knowledge and skills. Jonassen and Land (2000) described objects of activity systems as artifacts that were produced by the system. Whether physical, mental, or symbolic, these products were acted on by the subject. The purpose behind mobile technology was to provide convenient access to information (Traxler, 2007). If Traxler (2007) was correct that mobile technology did provide convenient access to information, then Sharples et al. (2005) framework for object must be changed. However, the studies by Liaw et al. (2010) and Sharples et al. (2005) were examples of how activity theory could be used as a theoretical framework for mobile learning.

2.4 Potential Issues With Mobile Learning

There are potential issues with using mobile technology for learning that can negatively affect student performance. Each of the issues should be properly addressed before mobile technology-based activities for instruction are developed. These potential issues include providing student access, misuse of digital content, communication etiquette, safety, security, student support, instructor support, institutional infrastructure, policies that support using mobile technology, device limitations, app testing, device contamination, distraction, multitasking, and using class time adequately. Franklin (2011) listed access, misuse of digital content, communication etiquette, safety, security, student support, instructor support, and institutional infrastructure as the potential issues for mobile learning. The socio-economic situation of the students could prevent equitable access to the mobile technology. The issue of cost to access and
maintain mobile connectivity was a critical limiting factor for many students. Institutions must address the need for supplemental mobile technology for students that cannot afford a mobile device. The digital content misuse can range from illegal to unethical. Illegal issues may include downloading pirated music, cyberbullying, hacking networks, and sending viruses. Unethical issues may include plagiarism, sharing assignments, and cheating on exams. Communication etiquette for learning with mobile technologies needs a standard. Students need to know when to silence their phones, because ringing phones can be a distraction in the classroom. In addition, there are safety issues with mobile technologies such as eyestrain, hearing damage, repetitive stress injury, and possible unknown health issue from constant exposure to mobile technology (Franklin, 2011). Security issues with mobile technology can include protecting mobile access to credit cards and bank accounts. These accounts and the mobile device must be password protected to prevent illegal access and theft. Mobile devices can distract students when they or their classmates post to Facebook or Twitter accounts instead of listening to lectures. Student support for mobile technology may vary based on the level of expertise each student has with the embedded tools in their own technology. Some students need devices and other need training to learn the capabilities and tools built-in their devices. These tools in the classroom require the instructor to have an understanding of mobile technology, or the institutions needs to provide professional staff to support the instructor (Franklin, 2011). Without professional development or adequate instructional support, instructors could be resistant to changing the way they have taught for years. Instructor resistance to this technology could significantly slow the adoption of mobile technology-based activities. Some instructors will resist changing because mobile technology could increase their workload. For example, instructional material and activities for mobile technology would change the way instructors keep office hours and course assessments.
A balance must be created between the 24/7 access that mobile technology provided students to the instructor, and the instructors personal time away from the institution (Franklin, 2011). Educational institutions need to plan financially for long-term support of the infrastructure and professional development for staff and instructors (Franklin, 2011).

Many educational institutions need new policies to support mobile technology-based activities. Policies changes that support mobile technology in the classroom require an investment in financial and human resources by the institution. An example of the type of financial investment that institutions need to make is the installation of wireless internet access points (Aerohive, 2013). These access points allow students to connect with their mobile devices in class. The access point software could be used to regulate and restrict access to certain information. The wireless internet access points come with management software that provides the instructor with the ability to see what each student is looking at on their device. This way the instructor could help a student that was on the wrong online activity (Aerohive, 2013).

Frohberg et al. (2009) discussed how some students might come to class with a very limited knowledge about their own device. These students may be able to text and make phone calls, but they need significant support when starting to use mobile technology for learning. Scaffolding is necessary to support student learning with mobile technology-based activities. During initial activities, students need additional guided assistance and support for learning. After students learned more about working the technology, the instructor could remove some of the scaffolding that provided student support. The reduction in scaffolding can increase student motivation and control over their learning (Frohberg et al., 2009).

Fisher and Baird (2006) used a survey of 235 students in a business communications course. They found that mLearning or mobile learning provided students with active learning and
collaboration. However, institutions must keep in mind the constraints and limitations of the mobile learning environment when developing activities. Content must be designed to fit on the small screen. Small screen size limits the amount of text that can be read on a mobile device. Designing activities for mobile devices also require the designer to account for the limited memory and battery of most mobile devices (Fisher & Baird, 2006).

Kiernan and Aizawa (2004) conducted a study to evaluate mobile phones used by students in Japan learning English (Kiernan & Aizawa, 2004). Mobile devices were popular learning tools with students in their study. The students used their mobile phones to send email messages to each other outside of class in English. The students learning English were able to use mobile phones as effectively as students using a PC. The disadvantages of mobile phones were short message length and the limited one finger input for messaging. Kiernan & Aizawa (2004) pointed out that the new features for videos and photos in modern mobile phones were potentially useful for verbal communications.

An increasing number of apps have been made available for the healthcare industry (Visvanathan, Hamilton, & Brady, 2012). These apps were for patient management, diagnosis, and education. According to Visvanathan et al. (2012), the accuracy and reliability of the apps have become a concern. They were concerned that the apps had not been through a peer-review process before being used for patient treatment. Visvanathan et al. (2012) recommended that regulatory measures be put into law to protect patient safety. The apps in their study were from the field of medical microbiology. For example, the variety of the apps included antibiotics, educational, reference, clinical, and understanding disease. Visvanathan et al. (2012) concluded that smartphones apps had many uses in medical microbiology, but these apps needed to be regulated and peer-reviewed to reduce the possible risk to patients.
Mobile devices have been ubiquitous in many clinical environments (Brady, Verran, Damani, & Gibb, 2009). These devices have been used to deliver healthcare to patients. Mobile technology has many benefits for healthcare, but this technology must be carefully handled and appropriately managed in the clinical, laboratory, and staff areas. The introduction of mobile devices into a laboratory or medical facility could potentially cause new safety issues related to contamination and infection. Studies have shown that mobile devices could be contaminated with pathogenic microorganisms (Brady et al., 2009).

Brady et al. (2009) had four recommendations for properly using mobile devices in a healthcare or laboratory environment. First, staff education is needed to make sure everyone knows about proper procedures for infection control. This can be done with posters and leaflets reminding staff and visitors to the medical facilities about the potential for contamination of their mobile devices. Second, hand hygiene needs to be addressed with mobile devices because the microorganisms could be transferred from the device to patients. Third, the safe use of mobile devices needs to be restricted to only specific areas to prevent infectious microorganisms from traveling into designated clean spaces in the medical facility. For example, the operating rooms could have restrictions on the use of mobile devices to prevent infections. Fourth, a mobile device needs to be properly cleaned. Medical facilities may need to require the same decontamination procedures that are used on other equipment to be used on mobile devices. According to Brady et al. (2009), many of the manufactures of mobile technology do not recommend most of the laboratory disinfecting and cleaning agents available for medical equipment.

Tesch, Coelko, and Drozdenko (2011) surveyed 81 undergraduate and graduate students to determine what distracted in them in the classroom. They found external and self-produced
distractions. The highest rated external distractor for the students in the survey was an instructor that was difficult to understand. The next two highest rated external factors were students talking and the temperature of the room. Mobile technology was fourth on the list of external factors. A ringing phone in class was the example of an external technology distraction. The top rated self-produced distraction was illness. Coughing, sneezing, and sniffing were included as examples of the illness distraction. According to Tesch et al. (2011), students were minimally distracted by others texting, surfing the internet, sleeping or drinking.

Campbell (2006) studied the challenges associated with mobile phones in college classrooms. His study surveyed faculty and students and determined their attitudes concerning mobile technology distractions and policies that restricted the technology. The survey data indicated that both faculty and students thought that a ringing phone in class was a distraction. Additionally, a vibrating phone on a desk was described as just as large of a distraction. The survey data indicated that faculty and students supported restricting mobile phones from ringing in class. According to the survey, the age of the person was a factor in their tolerance of mobile technology. The younger participants in the survey were more tolerant toward the technology (Campbell, 2006). Campbell’s (2006) findings from this study showed that faculty and students would support policies that banned phones from ringing in class.

According to Brazeau and Brazeau (2009), they and their pharmacy students were not accomplished multitaskers. They described the phones and computers in the classrooms as a distraction from teaching and learning. These devices with multitasking functions diverted students from focusing their attention on the material to be learned. According to Brazeau and Brazeau (2009), students need to stay focused for deep and lasting learning to occur, but the extra media sources that were available on their mobile devices distracted students from focusing
on learning. They suggested that students should turn off their technology to minimize the
disruptions and take some time to read and learn (Brazeau & Brazeau, 2009).

The more time students spend during class engaged with the class material the better their
academic achievement (Clough, Smasal, & Clough, 1994). Clough et al. (1994) discussed a cost
effective way to increase the students engagement time in class was to reduce or remove the
factors that distracted students from their task. At the beginning of class, students should be
given task that requires them to go to work as soon as they walk into the room. For example,
students could be writing down the daily activity into a journal or a lab report. To get the
students engaged with the course material for increased academic achievement, then classroom
time needs to be focused on learning activities. At the end of class, students should be
discouraged from gathering their things and socializing. Students need to be engaged on the task
to be learned until class was dismissed (Clough et al., 1994).

2.5 Research About Mobile Learning

The research studies in this part of the literature review focus on student learning
outcomes. These studies consisted of surveys, questionnaires, focus group, quasi-experimental,
and experimental studies. Several of the researchers in these studies used empirical data
including analysis of pretest and posttest, group comparison, and effect size. The review revealed
four major themes on learning supported by mobile technologies: improved performance, motivation, student engagement, and convenience and easy access for learning.

2.5.1 Improved Performance

Improved performance has been highlighted as an important factor for mobile learning.
Hsu and Lee (2011) discussed a study where Taiwanese college students learning English were randomly selected into an experimental group and control group. The experimental group used their mobile devices to do their assignments, and the control group received instruction without mobile devices. Each group was pretested for their English proficiency. The groups were not significantly different in their English proficiency. The experimental group used the mobile devices to practice their English by sending text messages. The control group used traditional instruction. The experimental group outperformed the control group on the posttest. Pretest and posttest compared by dependent samples t-test indicated that both groups improved significantly. Data analysis of the pretest and posttest averages between the control group and the experiment group were significant. The experimental group scored significantly higher than the control group. A large effect size was determined between the groups. According to Hsu & Lee (2011), most of the students in the experimental group were positive about learning with their mobile phones (Hsu & Lee, 2011).

Liu, Tan, and Chu (2009) reported a study where elementary school students participated in an experiment that had one group of students using a PDA and the control group of students using handouts in a natural science class. The participants included four natural science teachers and over 70 fifth graders from the Experimental Elementary School of Taipei Municipal University of Education. The students in the experimental group were provided PDAs to download information from radio frequency identification (RFID) tags. The RFID tags provide students information related to the environment. The control group was provided handouts that went over the same information the experimental group received from the PDAs. The two groups were pretested to determine any differences in the prior knowledge. The differences between the two groups were insignificant. This indicated that the prior knowledge of the two groups of
students were similar. The student learning outcomes were tested to determine any differences between the groups. The experimental group outcomes of the ANCOVA were statistically significantly higher, than the control group with a large effect size. The average grades of the experimental group exceeded those of the control group by at least 13 points (Liu et al., 2009).

A study of several elementary schools in Southern Taiwan used an Interactive Concept Map-oriented Mindtool for Mlearning (ICM³) (Hwang, Wu, & Ke, 2011). The mobile activity had students learning about butterfly ecology in the field. Before the fieldwork started, the students were told to make a concept map about butterfly ecology. The students were randomly assigned into the two study groups. These groups both took a pretest about butterfly ecology. There was no significant difference between the two groups prior knowledge about butterfly ecology. The students in the control group were allowed to browse their concept maps, access supplemental materials, observe the butterfly ecology, search for data on the internet and modify their concept maps via their mobile devices. The experimental group used the same equipment to learn with ICM³. This tool helped students to make a concept map about what they saw in the field. After conducting the mobile technology-based activity, the groups took a posttest. According to Hwang et al. (2011), these students in the experimental group that used the ICM³ method on their mobile device did significantly better and had a more positive attitude than the control group. The students that were using the ICM³ method had a high effect size for the posttest scores (Hwang et al., 2011).

Fifth grade students at Cimarron Elementary School in Katy, Texas used mobile devices in a pilot program for math and science and increased their test performance on a standardized exam (Dickerson & Schad, 2010). According to Dickerson & Schad (2010), the students that used mobile devices had increased time on task as compared to prior fifth grade classes that
received traditional grade instruction without mobile devices. These students using the mobile devices scored higher than the other fifth graders using traditional instruction on the standardized test in math and science. The devices had software that allowed students to do more of their schoolwork at home. Additionally, the teachers in this pilot program were given training, technical support, how to guides, and mobile learning lesson plans. These teachers meet regularly and discussed the program and additional lessons (Dickerson & Schad, 2010).

2.5.2 Motivation

Motivation was another factor cited as an important reason for mobile learning. Mobile device activities were designed for elementary school students in a Taiwanese culture course (Hwang & Chang, 2011). Students went on a field trip to learn about local culture. The researchers divided the students into two groups. Each group was pretested to determine any difference between them. No significant difference was found between the groups on the pretest. The experimental group used formative assessment-based mobile learning (FAML). The students would move from location to location learning and answering questions related to the location. The experimental group was given a hint from the mobile device application, if they missed the question. The students in the control group used mobile devices to help tour the area, but they did not use the FAML method on their devices. When the students in the control group missed a question, they instantly got the correct answer. The ANCOVA comparison of the two groups on the posttest showed that the experimental group outperformed the control group. The Cohen’s d effect size for this study was between medium to large (Cohen, 1977). According to the researchers, the FAML was designed without the answers, and this design led to higher learning motivation and better scores on the posttest. The students in the experimental group were
required to find their own answers. During the learning process, these students were more motivated than the students in the control group because the control group was given the correct answer in their feedback (Hwang & Chang, 2011).

Elementary school students in Taiwan used PDAs to explore the historic Temple of Peace (Shih, Chuang, & Hwang, 2010). While the students moved through the temple, they were given hints about questions related to parts of the Temple on the PDAs. When the students had open-ended questions, they could search for the answers using Google. They recorded their answers in the note section on the PDA. Next, the students returned to their classrooms and discussed their experience learning about the Temple. One of the classroom activities had the students organize their notes from the field with the other students. Learning achievement was measured using pretest and posttest. After the fieldwork and classroom discussion activity, a posttest was administered. The posttest results were statistically significantly higher. The researchers used a questionnaire to ask the students questions about using the PDAs for their learning. For example, the students were asked if field learning was more interesting with the PDAs than teacher-guided. Over 90% of the students agreed that using the PDAs was more interesting than teacher-guided learning. When asked if the PDAs increased their motivation to learn, over 90% of the students agreed that it did increase their motivation. The results of both the posttest scores and the questions and answers, indicated that students were motivated by the PDAs and learning achievement improved (Shih et al., 2010).

Forty-two fourth grade students used PDAs to learn about biological science. These students were using PDAs to learn how to identify plants in a butterfly ecology garden (Hwang, Chu, Shih, Huang, & Tsai, 2010). The researchers provided PDAs to the students. The students used the information from the PDAs to guide themselves in plant identification. The pretest and
A posttest comparison showed a statistically significant increase in the ability to identify the plants by the students. A limitation of this study was a lack of a comparison group. After the students had participated in the plant identification, the teachers completed a survey about using PDAs to help their students learn. Most of the teachers indicated that this type of system could motivate student learning. When the students were surveyed, they indicated their motivation to learn was high because of using the PDAs. The researchers found the PDAs to be convenient and easy for the students to use. Additionally, the survey results showed that no matter whether students used the PDA before or not, they believed that using one for learning would be interesting and helpful (Hwang et al., 2010).

According to Liu et al. (2009), the environment of ubiquitous learning with educational resources (EULER) and database technologies could be used to develop activities for anytime and anywhere learning. The survey results indicated that most of the experimental group found the EULER method easy to use. Additional questions revealed that the experimental group was more motivated to learn than the control group because of the technology-based activities. The significance of this research demonstrated that mobile technology could improve student learning in outdoor environments (Liu et al., 2009).

The purpose of the research was to introduce and develop a teaching method that incorporated smartphones and QR Codes to learn about biology (Jun-Ki, Il-Sun, & Yong-Ju, 2011). The significance of this study showed that students could effectively learn biology with QR Codes and smartphones. Traditional field guides contain large amounts of complex information that may confuse students. The QR Codes only needed the central information for students to identify the organisms. According to Jun-Ki et al. (2011), QR Codes and smartphones motivated interest in learning about natural fauna.
Korean high school students used smartphones and QR Codes to scan and learn about aquatic species discovered in tidal mudflats. Jun-Ki et al. (2011) used QR Codes for species identification as a way to help students learn the organisms. Students used their smartphone scanning application or QR Code Reader to identify the species during field observation. Each QR Code about the species identified was stored in the QR Code application for later retrieval. The students shared their results and data using SMS or a social networking system. The students were able to communicate in real time by SMS and posting their findings on social networks. The ability to discuss their findings in a virtual space increased their communication and motivated their interest in learning.

Researchers reported that students using mobile technology were more motivated to learn. These five studies supported the theme that mobile technologies helped motivate student interest and improve their performance on exams. In the study by Hwang & Chang (2011) that used a FAML method to help students learn about local culture the researchers said, “The students were motivated to find their answers on their own.” According to Shih et al. (2010), after the students used PDAs to learn about a historic temple, they answered survey questions about their experience. Over 90% of the students said they were motivated to learn about a historic temple because of the PDAs. In another study, PDAs helped students learn about butterfly ecology. The teachers described their students using the PDAs as more motivated (Hwang et al., 2010). Liu et al. (2009) study with EULER said, “The students in the experimental group were more stimulated to learn than the control group.” Jun-Ki et al. (2011) described the students as being more motivated to learn because of the QR Codes and smartphones.
2.5.3 Student Engagement

Hawkes and Hategekimana (2009) compared student-learning outcomes after the introduction of tablet mobile technology in several courses. Freshman and sophomore students in their study were introduced to tablets in four different subjects: college algebra, English composition, business applications programming, and history (world civilization). The researchers compared courses before and after tablet PC implementation. According to Hawkes and Hategekimana (2009), the syllabi, textbooks, and other parts of these courses had not changed, so the researchers were able to control for variables. The four courses had the same materials, sequence, assignments and assessments. None of the classes had a negative impact on student achievement as the result of introducing tablets into class. Additionally, a significant positive improvement in student learning outcome was found in college algebra between the control group and mobile group. The students in the mobile group outscored the students in the control group. One of the reasons for the improved student success was increased engagement in the group using the mobile devices (Hawkes and Hategekimana, 2009).

In an experimental designed research study, two fifth grade classes from an elementary school in northern Taiwan were randomly selected into an experimental group and control group (Hsiao, Lin, Feng, and Li, 2010). The experimental group used PDAs with location-based services to learn about mangrove ecological systems as the teaching method. The control group was human guided and used learning materials and a worksheet as the teaching method. Pretest scores were used to compare the two groups for prior knowledge about the outdoor ecology. The pretest scores were compared for equality of variance between the two groups. The pretest confirmed that the two groups had equal prior knowledge about mangrove ecology. The PDA system helped students to learn about ecology. This study was significant because it
demonstrated a method that used mobile technology-based activities for outdoor lessons and ecology. One-way analysis of variance (ANOVA) for independent samples compared scores between the groups. The experimental group scored statistically significantly higher than the control group. According to Hsiao et al. (2010), the students in the experimental group helped each other and worked together during the activities. When students in the experimental group entered a particular area to learn about the ecology, their PDA received a signal and automatically presented the new information about the area to the students. These students spent several minutes longer than the control group engaged in learning about these areas. After they completed their task on the PDA, they would go to another area. The students in the control group only spent five to ten minutes in an area before moving to another area (Hsiao et al., 2010).

Singaporean middle school students used smartphones at school and home to learn their lessons in science (Norris et al., 2011). According to Norris et al. (2011), the additional time on task learning about science with their smartphones helped the students in the class (experimental group) significantly outperformed the five other classes (traditional instruction) on a standardized exam. One factor helped to improve student-learning outcomes was access to an easily carried smartphone. Another factor was the development of engaging learning activities created specifically for mobile devices (Norris et al., 2011). The students used the camera on the smartphone to photograph plant parts that were related to the lessons at school. For example, while at home the students took images of tree roots for class because they were studying the root system of plants. Then their plant images were discussed later in class. According to the study, the teachers for the experimental group used software applications called Sketchy,
PicoMap, and Mobile Word to create engaging learning activities for the student’s smartphones (Norris et al., 2011).

According to Rogers, Price, Randell, Fraser, Weal, and Fitzpatrick, (2005), mobile devices (PDAs) connected to wireless networks enabled children to access, compare, and input information from the soil probe while in the field. The PDAs and soil probes help to engage the students learning about soil and habitats. The students were able to integrate real world activities in the field and classroom activities by using mobile technology to learn about the habitat. Rogers et al. (2005) tried to get children to understand the ecological habitat relationships with plants and animals by using PDAs and probes in the field. During the study, the elementary school students in the United Kingdom used soil probes to measure the soil moisture and temperature. The students recorded the soil measurements on their PDA. After measuring the different soil areas in the field, they returned to class to compare the data collected. Additionally, they were learning about plants and animals in a real and digital world setting. They recorded the plants and animals observed and shared their observations with the other students. At the end of the study, the students were asked to develop a hypothesis about the environmental conditions in the field (Rogers et al., 2005).

2.5.4 Convenience and Easy Access for Learning

The convenience and easy access for learning was also cited as an important reason for mobile learning. Students in an introductory course in sociology were given the opportunity to use mobile technology-based software (McConatha, Praul, & Lynch, 2008). The HotLava Software assisted students in preparing for exams. The software had practice and review questions for students to learn on their mobile device. The software would work on multiple
types of devices. Forty-two of the 112 students in the course used the software to assist their learning. The exam averages between the group that used the software on their mobile device was compared to the group that did not use the software to prepare for the exams. The students that used the software on their mobile device had higher performance on their scores. According to McConatha et al. (2008), the convenient availability of information and resource were strong reasons for using mobile learning.

Spanish reading curriculum was pre-loaded into mobile devices for first graders in a Mexican elementary schools (Kim, Hagashi, Carillo, Gonzales, Makany, Lee, & Gàrate, 2011). The students had more interest in using the mobile devices than their teachers or administrators. Kim et al. (2011) described mobile devices as highly portable, easily distributable, affordable, and complemented education. The mobile device activities allowed the students to listen to a narration of the story, or the student could read the story aloud while recording. Then the students could listen to their own reading. This way they could compare their reading with the narration. The study was conducted at a rural and urban school. The rural school group was divided between the experimental group that used mobile technology and the control group that used existing educational materials. Additionally, the urban group was divided between the experimental group that used mobile technology and the control group that used existing educational materials. Kim et al. (2011) looked at the use of the technology and location during their analysis. Each group was pretested to determine any differences in prior knowledge. The average pretest scores for the rural group were compared to the average scores for the urban group. The pretest scores indicated that the groups were not significantly different. The scores of the students in the rural school experimental group were significantly statistically higher than the urban schools experimental group. The rural experimental group had the highest improvement
between pretest and posttest. The effect size between pretest and posttest was very large. According to Kim et al. (2011), the reason why the rural group outperformed the urban group was parental involvement and higher economic status in the rural group. 2011).

Mobile devices were used to enhance student’s learning about tree growth at a river restoration site in Indiana (Rogers, Connelly, Hazlewood, and Tedesco, 2010). This study looked at how students made sense of the habitat restoration. Students made scientific tree measurements and completed activities using their PDA. The first part of this study, groups of students were provided one PDA to look up information, enter data, and communicate with other groups. These students in this study used a PDA with a software application to learn about trees in the field and to observe different planting methods. Moreover, the application provided the students with additional information about the trees and the environment. The application also allowed the students to input data and share information with other groups. The first part of the study had too many activities for the student to complete with only one PDA. During the second part of the study, the groups of students were provided two PDAs, and one person was given the job of data entry while the other person used their PDA to look up information and send messages to the other groups. Using two PDAs reduced the time students spent waiting to complete their fieldwork activities. The additional PDA allowed the groups to easily access, share, and collaborate more information (Rogers et al., 2010).

In summary, these studies supported the mobile technology themes for student learning. Improved performance was backed by the research that had students using mobile technology and increasing their exam scores compared to students that did not use mobile technology. Motivation was supported by the research that demonstrated that mobile technology motivated students to learn. Student engagement was supported by research that described student using
mobile technology to engage in learning. The convenience and easy access for learning was supported by research studies that described the importance of access to technology for improved performance.

2.6 Exemplary Educational Objectives and Student Learning Outcomes

Any college curriculum must meet the requirements for Texas Higher Education Coordinating Board (1999). These rules and regulations must be followed because of the State of Texas laws for college funding. The Texas Higher Education Coordinating Board requires exemplary educational objectives for natural science courses in the core curriculum (Core Curriculum: Assumptions and Defining Characteristics, 1999).

- To understand and apply method and appropriate technology to the study of natural sciences.
- To recognize scientific and quantitative methods and the differences between these approaches and other methods of inquiry.
- To communicate findings, analyses, and interpretation both orally and in writing.
- To identify and recognize the differences among competing scientific theories.
- To demonstrate knowledge of the major issues and problems facing modern science, including issues that touch upon ethics, values, and public policies.
- To demonstrate knowledge of the interdependence of science and technology and their influence on, and contribution to modern culture.

The core curriculum courses were transferable to any state college or university in Texas (Core Curriculum: Assumptions and Defining Characteristics, 1999). Student learning outcomes were used to measure if a student meets the exemplary educational objectives for the course.

As part of the Annual Improvement Plan (AIP), the data from course-embedded questions were used to determine how to improve student-learning outcomes. This process of internal data analysis from the AIP was required for state reporting and accreditation reporting to Southern Association of Colleges and Schools (SACS).
At the institution where I teach biology, assessments were accomplished through embedded questions in exams for exemplary educational objectives and student learning outcomes (Kilgore College Faculty Handbook, 2012). The biology faculty worked together and created the course curriculum, laboratory schedule, exam to meet the requirements of the exemplary educational objectives, and student learning outcomes. Because of these rules and requirements, the changes I made for my dissertation research were approved by the biology faculty to ensure the exemplary education objective for the course could still be completed.

2.7 Pilot Study

A pilot study was conducted in the Fall of 2012 to determine the feasibility of changing a traditional biology lecture and lab into a course that used mobile technology-based activities. It was necessary to learn the limitations of the student’s knowledge about using mobile devices for learning. For example, I learned that several of my students had never scanned a QR Code. Then I had to find out how these changes would affect students grades and attitudes. I also had to determine the impact changing the lab schedule would have on the laboratory staff. The laboratory staff provided the consumable materials before each lab started. The lab manager needed to know of any extra equipment that I required. The reason the lab manager had to know about my equipment was that I shared the biology department laptops with other instructors. The lab manager or the lab staff had to know when to move the laptops in and out of the labs. I needed to know how much time was required to make the activities. I had to test the QR Codes and the activities before I gave them to the students.

The lecture content was changed from a traditional lecture based instruction into a classroom that had the students using their mobile devices to scan QR Codes, or they used a
website URL to access the class information and activities. The number of students passing the exam increased with the mobile technology-based activities, than the traditional lecture. Next, the laboratory activities were changed to have students scan a QR Code, or they used a website URL to complete mobile technology–based activities in lab. The students accessed the activities and submitted answers to laboratory questions using their mobile device. The labs were divided between activities with and without mobile technology for comparison. The results of the pilot study indicated that student-learning outcomes on lab exam scores were statistically significantly higher when using mobile technology-based activities as compared to traditional handouts.

All instructors teaching that lab normally used the same laboratory schedule each semester. This saves the biology department money on consumable experimental products bought in bulk. Additionally, each change in the lab schedule increased the time required each day to setup for lab. This pilot study was limited to one month of laboratory content and one lecture exam, because it did not change the regular lab schedule. This change also saved the biology department some money on consumables.

Six different labs were on the exam. The labs were divided into the traditional handout laboratory activities and mobile technology-based activities. The three traditional handout laboratory activities included the following labs: enzymes, meiosis, and photosynthesis. The average scores were compared between the pretest and posttest for the handout activities and the mobile technology-based activities. Paired samples $t$-test compared the pretest and posttest averages. The analysis indicated a significant difference for one of the traditional handout lab activities (meiosis lab) between the pretest and posttest averages. The other two traditional handout laboratory activities did not have a statistically significant difference in the pretest and posttest scores.
The three mobile technology-based activities included the following labs: yeast, rabbit natural selection, and mitosis. Paired samples t-test compared the pretest and posttest averages. The analysis indicated a significant difference for the mobile technology-based activities for the yeast fermentation lab between the pretest and posttest averages. Further analysis indicated a statistically significant difference for the mobile technology-based activities for the rabbit natural selection lab between the pretest and posttest averages. The mitosis mobile technology-based activity did not have a statistically significant difference in the pretest and posttest scores. Additionally, the students missed twenty percent fewer questions on the part of the lab exam that used the mobile technology-based activities (179 missed) as compared to the part with handout activities (224 missed). The mobile technology-based laboratory activities had a positive effect on the student performance.

As I was conducting this piloting study, I learned that some of the student’s cameras and the QR Code readers were not effective at scanning. I found it beneficial to put the students in small groups, so they could help each other with their technical problem. When I put the students into the small groups, I made sure that each group had at least two people that had their own smartphone or another type of mobile device. The small groups worked together to resolve many of the simple technical issues before I was asked to help. This freed up my time to work with the students that had problems viewing the content after scanning the QR Code. For example, one of the students used a QR Code reader than would not allow the smartphone to change to the wide view. This prevented her from seeing all of the activity. She downloaded two or three other QR Code readers before one of the readers would allow the wider view on her smartphone. I learned that the students wanted automatic feedback built-in to the activities. After submitting their activity, the students in the pilot study wanted to know if they got the answer correct.
immediately, so I had to modify the activities in this study to provide them feedback on the question and answer activities. In this research study, I changed how the activities were being graded from individual answers to completion of the activity. This was necessary to keep the grading the same for the two groups.
CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this study was to determine if mobile technology-based activities improved student performance in a biological science course. This study compared two groups of students in two non-science majors biology courses. All of the participants were undergraduate students at a rural community college in Eastern Texas. The students in these courses were representative of the general student population.

3.2 Research Design, Procedure, and Participants

3.2.1 Design

The research methodology for this study was a quasi-experimental design between the instructional method for the mobile group that used mobile technology-based activities and the non-mobile group that used handouts in biological science courses. The students were not intentionally randomly assigned to the courses, that is, students enrolled themselves into the courses in this study. The study used formative (quizzes) and summative (exams) assessments to compare student performance. Additionally, the questions for the quizzes and exams were validated from the textbook provided instructor resources. Subject matter experts in anatomy and physiology authored the questions. Additional subject matter experts for reliability edited the content and supplemental instructional resources.

3.2.2 Procedure

In this study, the students in the experimental lecture were called the mobile group. The
mobile group received mobile technology-based activities. The students in the control group were the non-mobile group, and the non-mobile group received traditional lecture and laboratory instruction and handouts. Students in the mobile group were told that having a mobile device for the course was highly recommended. If a student forgot their device, the instructor provided a device for them to use during class. The students worked on the mobile technology-based activities in teams and individually. During the lecture or lab, students accessed the activities by way of smartphones, tablets, or laptops. The students were able to use the college provided wireless internet access to download the activities. This provided students with an option that did not require them to use their own data plan to pay for retrieving the activities. Students in non-mobile group were prohibited from using their mobile device in lecture or laboratory. The quantitative part of this research compared quizzes and exam scores between the mobile group and the non-mobile group. Both groups were given the same quizzes and exams. Additionally, the students were surveyed to determine the options related to using mobile technology for learning. The qualitative part of this research was to determine what benefits and challenges students encountered in their learning during the mobile technology-based activities. To answer these questions students were interviewed. The interviews were designed as a focus group.

3.2.3 Participants

This research study compared the effect of mobile technology-based activities on student performance on exams and quizzes. The students in the experimental lecture were called the mobile group. The students in the control group were the non-mobile group. The students in the non-mobile group had lectures with handouts over the same content as the students in the mobile (experimental) group.
The anticipated population was about equal numbers of male and female students. The actual numbers were 60% female and 40% male. The racial-ethnic demographics of the participants were the following: 71% white, 10% African American, 15% Hispanic, 2% Asian, 2% Native American. The majority of the students, 85%, were between 18 and 24 years old. The students were the following ages: 38 between 18 to 24 years old, 2 between 25 to 30 years old, and 4 between 31 to 40 years old.

3.3 Measurement

The quantitative data analysis was divided into the following: pretesting for prior knowledge, lecture quiz and exam comparison, lab quiz and exam comparison, and student survey response analysis. Next, to determine any significant difference in the prior knowledge of the two groups, a course pretest was given. The pretest scores were compared to test the assumption of homogeneity of variance between the groups. The homogeneity of variance test that the variance within each group was equal. The two groups were compared by a one-way analysis of variance or ANOVA test. The ANOVA compared whether or not three or more means are equal. The software PASW Statistics GradPack 18 for Windows, a product of SPSS Inc., was used to perform the statistical analysis. The two groups were compared to determine if there was any statistical significance between the exam scores and instructional method. The quiz scores and instructional method were compared by ANOVA to determine any statistical significance. Next, the procedures, and methods used for collecting and analyzing the quantitative data for lecture, lab, and survey responses.

3.3.1 Pretests and Posttests

Biology departmental pretest determined baseline knowledge of the subject. At the end of
the semester, the students received a posttest to establish any improvement in their scores. The class average for the pretest and posttest were part of the departmental data submitted annually for student learning outcomes for State of Texas Annual Improvement Plan reporting and SACS accreditation. The questions used in the departmental pretest and posttest were from the textbook by Elaine Marieb, *Essentials of Anatomy and Physiology*, 9th edition (2009).

3.3.2 Lecture Quiz and Exam Comparisons

Mobile technology-based activities were added to a biology lecture course. These activities were based on similar activities used in the pilot study. During the beginning of the semester, the instructor demonstrated how to use the mobile technology. For example, the instructor explained the purpose of a QR Code and the QR Code Reader. The students were told where find a QR Code Reader app for their mobile device. Next, the instructor explained how the app worked on the student’s mobile device. The QR Code Reader allowed the students to scan the QR Code to retrieve information. After scanning the QR Code, the information stored on QR Code was accessible on their mobile device. Students could retrieve these activities, as long as, they had internet access on their devices. The QR Codes were made by the instructor to provide the students with quick access to the website with activities and content. The instructor used an online QR Code generator application on Google.com to generate the QR Codes. The students that did not have a mobile device to scan the QR Code were provided a link to a website that had the same activities and content (see Appendix A for QR Codes and web links for lecture activities). The link to the web page was made with a website called www.tinyurl.com. The website allowed the instructor or student to create new links to websites that are smaller than the original. The original uniform resource locator or website links were over 70 characters long.
The app on the tinyurl.com website reduced the long website address to 26 characters long. Once all of the students had access to the activities, they practiced entering data and answering questions with their device. After the students entered their practice activity, the instructor showed the students how the data was submitted online.

At the beginning of the semester, the students were divided into teams. Then the students worked with their teams to complete the mobile-technology-based activities (see Appendix B). The instructor picked the teams to make sure that each team had several students with mobile devices. Later in the semester, the students worked on the activities individually. Some of the activities required the students to use either www.polleverywhere.com or text answers to the instructor’s computer from their mobile device. All the information and questions that were answered with the mobile devices were graded based on completion of the activities (see Table 3.1 for list of activities in lecture). For example, the activity over the skeletal system required the students to label the bones of the human body and submit their answers using their device.

The non-mobile group received instruction in the form of lecture and handouts. Classroom activities included assigned reading and handouts that covered the same material as the mobile group. During the lecture, students were told to take notes over the material covered in class. The quizzes were over the material covered in the lecture and the assigned reading. For example, the skeletal system handouts had lists of the bones to sort into the two different divisions of the skeletal system. The students in the non-mobile group were divided into teams to work together on the handouts and class activities (see Appendix C for a list of classroom activities). Some of the activities required the students to use small white boards to write out the answers to share with the class. The students in the non-mobile group were given the same formative assessments (quizzes) and summative exams as the mobile group.
Each group was given the same number of quizzes to compare any differences between the groups. The quiz questions were from the textbook test bank of questions. Each quiz had ten multiple-choice questions. Both groups were given the same number of exams to compare any differences between the groups (see Appendix D for the sample of the lecture quiz and exam). Each exam was over four different chapters. The exam questions were also from the test bank of questions. Each exam consisted of 100 multiple-choice questions.

### 3.3.3 Lab Quiz and Exam Comparisons

This laboratory course was for non-science majors. The comparison of the two groups in the lab consisted of three lab exams and eight quizzes (see Appendix E for the lab schedule). Every student was required to have a laboratory manual. All of the content covered in the lab was from the *Essentials of Human Anatomy and Physiology Lab Manual 5th* edition by Marieb (2012). The students conducted experiments to learn how to identify the parts and functions of the human body. Some of the experiments required them to compare animal dissections to the
human body. Many of the experiments and activities have been part of the biology course and lab manual for years. The content in each activity was the same for each group. The laboratory activities were designed to help students reinforce their learning in lecture. The mobile group used mobile technology-based activities (see Table 3.2 for a list of the lab activities). These activities required the students to use their mobile devices to learn about the lab activity and submit answers to questions (see Appendix F for QR Codes and web links to lab activities). The non-mobile groups had activities that covered the same content as the mobile group, but the activities included assigned reading and handouts. Both activities had the same content for each group to learn. Activities were graded based on the completion of the assignment. The mobile technology-based activities for lab were on several websites (see Appendix G for mobile group lab activities). The non-mobile group completed laboratory activities and handouts (see Appendix H for non-mobile group sample lab activities).

Table 3.2

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<tr>
<th>Mobile Group</th>
<th>Non-Mobile Group</th>
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<tr>
<td>Mobile Technology-Based Activity</td>
<td>Handout Activity</td>
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<tr>
<td>Lab Experiment</td>
<td>Lab Experiment</td>
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<td>Data/Summary</td>
<td>Data/Summary</td>
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<td>Lab Quizzes</td>
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<tr>
<td>Lab Exams</td>
<td>Lab Exams</td>
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During the beginning of the semester, the instructor demonstrated how-to-use the mobile technology. For example, the purpose of a QR Code and the QR Code Reader app was demonstrated. The students were told where find a QR Code Reader app for their mobile device. The lab activities were accessed by provided the students with QR Codes and tinyurl.com. The
instructor explained to the students the potential issues of using a mobile device in the laboratory. These issues included distractions by the device during potentially hazardous experiments and device damage from spills or chemicals. To address these safety issues, students were constantly reminded of proper hand washing techniques in the laboratory. The students were provided safety guidelines to prevent the contamination and damage to their mobile devices (see Appendix I for the Safety Guidelines for Mobile Devices in Lab).

Once all of the students understood the issues with the technology in lab, they were told to practice entering data and answer the practice questions with their device. After completing practice activity, the instructor demonstrated how the data was submitted online. Biology labs are physically divided into separate areas that created small teams to work together on the laboratory activities. The small teams each had multiple people with mobile technology, so each team always had access to all the activities in the lab. In addition to the team assignments, the individual student had to complete lab activities submitted using mobile technology as an out of class assignment.

The non-mobile group was provided laboratory content and handouts from the instructor. These handouts covered the same laboratory content as the mobile group. The non-mobile group also participated in lab experiments in small teams. The small teams worked on handout activities together in the lab. The individual student had to complete lab handout activities as out of class assignment.

Just like the analysis in lecture, the two groups were compared by a one-way analysis of variance or ANOVA test. The ANOVA test compared whether or not three or more means are equal. The software PASW Statistics GradPack 18 for Windows, a product of SPSS Inc., was used to perform the statistical analysis. The two groups were compared to determine if there was
any statistical significance between the exam scores and instructional method. The quiz scores and instructional method were compared by ANOVA to determine any statistical significance. Both groups were given the same quizzes to compare any differences between the different instructional methods. The quiz questions were over the experimental results, safety issues, procedures, and activities. Each quiz had ten multiple-choice questions. Both groups were given the same exams to compare any differences between the groups using the different instructional methods. Each exam was over several lab activities. The lab exam questions were from the experimental procedures, experimental results, safety issues, and activities. Each exam consisted of 50 multiple-choice questions. The lab quizzes and exams were over the activities in the experiments (see Appendix J for sample lab quiz and exam).

3.3.4 Survey

This study used the survey questions from Lowenthal (2013) to provide background for the focus group interview questions on the benefits and challenges of using mobile technology-based activities in biology. Lowenthal (2013) conducted a survey to examine students’ behavioral intentions related to using mobile learning. The survey addressed the areas of student expectancy in performance, effort expectancy, and self-management of learning. Performance expectancy (PE) was defined as the extent to which an individual believed that using mobile technology would be helpful in acquiring knowledge and getting a better class grade. Effort expectancy (EE) was defined as the extent to which a student believed that the mobile technology for learning was easy. Self-management of learning (SL) was defined as the extent to which individual believed he or she was self-disciplined and could learn on their own. The results indicated the students who believed mobile learning was easy to do would only slightly
increase their likelihood to use this method as a learning strategy. The students felt that mobile learning would help increase their ability to learn, and they were likely to use this method as a learning strategy. The results of this study indicated that performance and effort expectancy answers from students acted as predictors of their behavioral intention (BI) for using mobile technology for learning. A strong attempt was made to ensure the validity of this study thorough the procedures that were implemented. Lowenthal’s study focused only on university students within a college/school of business. The use of self-report scales to measure study variables suggests the possibility of a common method bias for some of the results (Lowenthal, 2013). The survey questions were on a seven-point Likert scale. These questions asked the students about their ability to manage their own learning, performance expectancy, effort expectancy, and intentions to use mobile technology for learning. Additionally, student demographic information was collected at the beginning of the survey (see Appendix K for Demographic and Survey Questions).

The survey data was analyzed using PASW Statistics GradPack 18 for Windows, a software product of SPSS Inc. Analysis of the student survey responses and exam scores were by Pearson product-moment bivariate correlation and regression analysis. The method of analysis used to compare the mobile group and non-mobile group answers on the survey was ANOVA. The two groups were compared to determine if there was any statistical significance between the responses to the survey questions. The survey items analysis for Self-management of Learning was compared to exam scores and instructional method by ANOVA. Regression analysis was used to determine any statistical significant difference between responses and exams. Additional analysis compared possible other independent variables on the dependent variable (exam scores).
The responses from the two focus groups were compared by ANOVA to determine any statistically significant difference in the two groups.

3.3.5 Focus Group Interviews

Several students from each group were asked to be interviewed to determine their opinion about the benefits and challenges of mobile technology-based activities for learning. The interviews were all conducted as a focus group. Each group was interviewed separately. The interviewer asked both groups the same questions. The focus groups were made up of students from both groups that volunteered to answer the questions. The interviewer was an associate of the researcher for this study. The interviewer read the instructions and the questions to the students (see Appendix L Interview Questions). The questions to the students were centered on the benefits and challenges of using mobile technology for learning. The interviews were recorded and transcribed. Next, two researchers coded the transcripts separately. The codes were generated and then collapsed into categories and themes. After comparing the focus group codes, we agreed on the categories and themes, which are reported in the following chapter.
CHAPTER 4
RESULTS

4.1 Introduction

This chapter is divided into research questions, statistical comparison of the two groups, survey results, and focus group interview results. The statistical comparison of the groups included: pretest and posttest results, lecture quiz and exam results, lab quiz and exam results, and combined lecture and lab exam results. The survey analysis included general results and Self-management of learning results. Focus group interview analysis resulted in three categories. The categories were named category of disadvantages, category of depends, and category of benefits. The category of disadvantages is supported by four themes. The category of depends is supported by two themes. The category of benefits is supported by three themes. Then a description of how the benefits and disadvantages of mobile technology-based activities related to the students experiences follows.

4.2 Research Questions

Research questions that the study sought to answer included the following:

- Did the mobile technology increase students’ scores on quizzes and summative exams in lectures? If so, how and why?

- Did the mobile technology increase students’ scores on quizzes and summative exams in labs? If so, how and why?

- What benefits and challenges did students encounter in their learning during the mobile technology-based activities?

4.3 Pretest and Posttest Results

The two groups were given the biology department lecture pretest at the beginning of the
semester to determine their prior knowledge of biology. The ANOVA analysis of the pretest scores were not statistically significantly different $F(1,32) = 1.29, p = .263$ between the mobile group and the non-mobile group. Additionally, the biology department posttest scores for the two groups were not statistically significantly different $F(1,27) = .23, p = .635$. Both groups statistically improved their scores. The mobile group improved their scores by an average 5.06, and the non-mobile group improved their scores by an average of 3.63 points per student.

4.4 Lecture Quiz and Exam Comparisons

The mobile group outscored the non-mobile group by an average of 6.6 points on the three lecture exams. The descriptive statistics of lecture exam scores between the groups were compared to the instructional method (see Table 4.1 for the lecture exam comparison between instructional methods for descriptive statistics).

Table 4.1

<table>
<thead>
<tr>
<th>Lecture Exams and Instructional Method</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lect_test1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-mobile group 1</td>
<td>22</td>
<td>66.55</td>
<td>12.33</td>
</tr>
<tr>
<td>mobile group 2</td>
<td>22</td>
<td>71.68</td>
<td>12.36</td>
</tr>
<tr>
<td>Lect_test2</td>
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<td></td>
<td></td>
</tr>
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<td>71.76</td>
<td>14.35</td>
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<td>mobile group 2</td>
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<td>79.59</td>
<td>14.02</td>
</tr>
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<td>Lect_test3</td>
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<td></td>
<td></td>
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<tr>
<td>non-mobile group 1</td>
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<td>68.55</td>
<td>14.26</td>
</tr>
<tr>
<td>mobile group 2</td>
<td>21</td>
<td>75.37</td>
<td>12.03</td>
</tr>
</tbody>
</table>

The Levene test of homogeneity of variance assumes that the variability between each
group was equal. The Levene results for the three exams are in Appendix M. These results indicated that the variability between the groups was equal.

Next, the lecture exam scores between the mobile group and the non-mobile group were compared with ANOVA. The results of the comparison indicated there was no significant difference between instructional method and the lecture exam scores between the two groups (see Table 4.2 for the ANOVA comparison between Instructional Method and Lecture Exams).

Table 4.2

ANOVA Comparison Between Instructional Method and Lecture Exams

<table>
<thead>
<tr>
<th>Lecture Exams and Instructional Method</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lect_test1</td>
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<td>1.750</td>
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<tr>
<td>Lect_test2</td>
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<tr>
<td>Lect_test3</td>
<td>39</td>
<td>2.756</td>
<td>.105</td>
</tr>
</tbody>
</table>

Note. The instructional method was for non-mobile group 1 and for mobile group 2. *p < .05.

The descriptive statistics compared the quiz scores between the two groups (Descriptive Statistics for Lecture Quizzes Comparison between Instructional Method). The mobile technology-based activities and the handouts covered the same material that was on the quizzes. The results between these two groups indicated that the mobile technology based activities did have a positive effect on the Quiz9 grades (see Table 4.3 for lecture quiz descriptive statistics). The lecture quizzes comparison between instructional methods was by ANOVA. The comparison between lecture quizzes and instructional method only had quiz9, $F(1,43) = 4.102, p = .049$, that was statistically significant (see Table 4.4). The mobile technology-based activity for Quiz9 did have videos over the material. The other quizzes did not have a statistically significant difference in scores (see Table 4.4). The Levene test of homogeneity of variance for the two
groups is in Appendix N. These results indicated that the variability between the groups was equal in this analysis.

Table 4.3

*Descriptive Statistics for Lecture Quizzes Comparison Between Instructional Method*

<table>
<thead>
<tr>
<th>Lecture Quizzes and Instructional Method</th>
<th>n</th>
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<td>Mobile Group 2</td>
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<td>5.57</td>
<td>2.51</td>
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<tr>
<td>Quiz2</td>
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<td>Quiz3</td>
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<td>Mobile Group 2</td>
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<td>2.81</td>
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<td>2.86</td>
<td>1.67</td>
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<td>2.79</td>
</tr>
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<td>2.74</td>
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<td>3.31</td>
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<td>2.74</td>
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<td>3.86</td>
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</tr>
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</table>
### Table 4.4

**Lecture Quizzes Comparison Between Instructional Method ANOVA**

<table>
<thead>
<tr>
<th>Lecture Quizzes and Instructional Method</th>
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<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>.548</td>
</tr>
<tr>
<td>Quiz2</td>
<td>43</td>
<td>.366</td>
<td>.548</td>
</tr>
<tr>
<td>Quiz3</td>
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<td>.288</td>
<td>.594</td>
</tr>
<tr>
<td>Quiz4</td>
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<td>.237</td>
<td>.629</td>
</tr>
<tr>
<td>Quiz5</td>
<td>43</td>
<td>.002</td>
<td>.960</td>
</tr>
<tr>
<td>Quiz6</td>
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<td>3.844</td>
<td>.056</td>
</tr>
<tr>
<td>Quiz7</td>
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<td>.022</td>
<td>.882</td>
</tr>
<tr>
<td>Quiz8</td>
<td>43</td>
<td>.019</td>
<td>.890</td>
</tr>
<tr>
<td>Quiz9</td>
<td>43</td>
<td>4.102</td>
<td>.049</td>
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<tr>
<td>Quiz10</td>
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<td>.189</td>
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<td>Quiz11</td>
<td>43</td>
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<td>.968</td>
</tr>
<tr>
<td>Quiz12</td>
<td>43</td>
<td>1.073</td>
<td>.306</td>
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</tbody>
</table>

*Note.* The instructional method was for non-mobile group 1 and for mobile group 2. *p < .05.*

#### 4.5 Lab Quiz and Exam Comparisons

The descriptive statistics of lab exams scores between the mobile group and the non-mobile group compared the instructional method, see Table 4.5. The mobile group scored an average of 10.4 points per exam higher than the non-mobile group.

Next, the lab exam scores between the mobile group and the non-mobile group were compared with ANOVA (see Table 4.6). The results of the comparison indicated a statistically significant difference between instructional method and the all of the lab exam scores. Eta-squared ($\eta^2$) tells the amount of variance in the dependent variable (exam scores) that can be explained by the independent variable (instructional method). The instructional method used two
versions of the classroom and laboratory content. The two groups were divided into one group of students (mobile group) who used the mobile technology-based activities, and one group of students (non-mobile group) that did not use the mobile technology-based activities.

Table 4.5

Lab Exam Comparison Between Instructional Method for Descriptive Statistics

<table>
<thead>
<tr>
<th>Lab Exams and Instructional Method</th>
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<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab_test1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
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<td>72.60</td>
<td>13.28</td>
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<tr>
<td>Mobile Group 2</td>
<td>23</td>
<td>83.04</td>
<td>10.95</td>
</tr>
<tr>
<td>Lab_test2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
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<td>77.14</td>
<td>14.96</td>
</tr>
<tr>
<td>Mobile Group 2</td>
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<td>85.61</td>
<td>11.06</td>
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<tr>
<td>Lab_test3</td>
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<tr>
<td>Non-Mobile Group 1</td>
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<td>70.76</td>
<td>8.50</td>
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<tr>
<td>Mobile Group 2</td>
<td>21</td>
<td>83.05</td>
<td>11.62</td>
</tr>
</tbody>
</table>

Table 4.6

ANOVA Comparison Between Instructional Method and Lab Exams

<table>
<thead>
<tr>
<th>Lab Exams and Instructional Method</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab_test1</td>
<td>41</td>
<td>7.984</td>
<td>.007*</td>
<td>.160</td>
</tr>
<tr>
<td>Lab_test2</td>
<td>42</td>
<td>4.609</td>
<td>.038*</td>
<td>.100</td>
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<tr>
<td>Lab_test3</td>
<td>40</td>
<td>15.280</td>
<td>.000**</td>
<td>.280</td>
</tr>
</tbody>
</table>

Note. Lab exams average score compared to instructional method. *p < .05. **p < .01.

The instructional method could explain sixteen percent of the difference in the two group’s first lab exam scores. The instructional method could explain ten percent of the difference in the two group’s second lab exam scores. The instructional method could explain twenty-eight percent of the difference in the third lab exam scores between the groups. The Levene results for the three lab exams are in Appendix O. The results indicated that the variability between the groups were equal.
Additionally, both group scores on the lab quizzes were compared with the instructional method. The descriptive statistics compared the mobile group and the non-mobile group quizzes scores and instructional method (see Table 4.7).

Table 4.7

Lab Quizzes Comparison Between Instructional Method for Descriptive Statistics

<table>
<thead>
<tr>
<th>Lab Quizzes and Instructional Method</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
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<td>Labquiz1</td>
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</tr>
<tr>
<td>Non-Mobile Group 1</td>
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<td>7.18</td>
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<td>Mobile Group 2</td>
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<td>3.15</td>
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<tr>
<td>Labquiz2</td>
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</tr>
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<td>Non-Mobile Group 1</td>
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<td>6.32</td>
<td>2.55</td>
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<tr>
<td>Mobile Group 2</td>
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<td>6.70</td>
<td>2.01</td>
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<td>7.13</td>
<td>3.50</td>
</tr>
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<td>3.29</td>
</tr>
<tr>
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<td>5.96</td>
<td>3.57</td>
</tr>
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<td>6.26</td>
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<td>4.78</td>
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<tr>
<td>Mobile Group 2</td>
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<td>6.39</td>
<td>3.13</td>
</tr>
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</table>

Note. The instructional method was for Non-Mobile Group 1 and for Mobile Group 2.

The lab quizzes comparison between instructional methods was by ANOVA. The lab quizzes compared mobile technology-based activities and handouts. The mobile technology-based activities had videos, fill in the blanks, and dissection help over the material. None of quizzes had statistically significant difference in the scores (see Table 4.8). Additionally, the Levene test
of homogeneity of variance for the two groups is in Appendix P. These results indicated that the variability between the groups was equal in this analysis.

Table 4.8

*Lab Quizzes Comparison Between Instructional Method ANOVA*

<table>
<thead>
<tr>
<th>Lab Quizzes and Instructional Method</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labquiz1</td>
<td>43</td>
<td>.418</td>
<td>.521</td>
</tr>
<tr>
<td>Labquiz2</td>
<td>43</td>
<td>.305</td>
<td>.583</td>
</tr>
<tr>
<td>Labquiz3</td>
<td>43</td>
<td>.288</td>
<td>.594</td>
</tr>
<tr>
<td>Labquiz4</td>
<td>43</td>
<td>.781</td>
<td>.382</td>
</tr>
<tr>
<td>Labquiz5</td>
<td>43</td>
<td>2.366</td>
<td>.131</td>
</tr>
<tr>
<td>Labquiz6</td>
<td>43</td>
<td>.845</td>
<td>.363</td>
</tr>
<tr>
<td>Labquiz7</td>
<td>43</td>
<td>2.998</td>
<td>.091</td>
</tr>
<tr>
<td>Labquiz8</td>
<td>43</td>
<td>.437</td>
<td>.512</td>
</tr>
</tbody>
</table>

*Note.* The instructional method was for Non-Mobile Group 1 and for Mobile Group 2. *p < .05.

4.6 Combined Lecture and Lab Exam Results

The exam scores were combined to examine the overall effect of the instructional method on student exam performance. The lecture exam scores averaged approximately seven points higher in the mobile group. The lab exam scores averaged ten points higher in the mobile group. The descriptive statistics compared the instructional method and the combined exams average scores between the mobile group and the non-mobile group, see Table 4.9.

Table 4.9

*Combined Exam Averages and Instructional Method Descriptive Statistics*

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Mobile Group 1</td>
<td>22</td>
<td>70.66</td>
<td>11.64</td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>23</td>
<td>79.14</td>
<td>10.17</td>
</tr>
</tbody>
</table>
The combined exam average scores were over eight points higher in the mobile group. Next, the exam scores between the mobile group and the non-mobile group were compared with ANOVA, see Table 4.10.

Table 4.10

*Combined Exams Averages and Instructional Method ANOVA*

<table>
<thead>
<tr>
<th>df</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>6.796</td>
<td>.013*</td>
<td>.140</td>
</tr>
</tbody>
</table>

*Note.* The combine exam averages was calculated from both lecture and lab. *$p < .05$.*

The results of the comparison indicated a statistically significant difference between instructional method and the all of the combined exam average scores between the two groups. The instructional method could explain fourteen percent of the difference in the combined exam average scores. The Levene test of homogeneity of variance for the combined exams is in Appendix Q. These results indicated that the variability between the groups was equal in this analysis.

4.7 Survey Results

The survey determined the performance expectancy (PE), effort expectancy (EE), behavior intention (BI), and self-management of learning (SL) with mobile technology for both groups. The original survey questions were from Lowenthal (2013). The survey questions were on a seven-point Likert scale. These questions asked the students about their expectancy. Performance expectancy was defined as the extent to which an individual believed that using mobile technology would be helpful in acquiring knowledge and/or getting a better class grade. Effort expectancy was defined as the extent to which a student believed that the mobile
technology for learning was easy. Self-management of learning was defined as the extent to which an individual believed he or she was self-disciplined and could learn on their own. Behavioral intention questions looked at the student belief that he or she will use mobile technology for learning in the future.

4.7.1 General Results

Lowenthal (2013) used Pearson product-moment bivariate correlation coefficient and regression analysis to try to predict behavioral intention from over one-hundred responses. The survey responses from the 44 students in this study lacked a correlation between self-management of learning and behavioral intention (see Table 4.11 Bivariate Correlation of the Student Survey Response and Exams). However, there was a correlation between exam scores for both lecture and lab, combine exam scores, instructional method, and self-management of learning (SL) (see Table 4.11). The bivariate correlation analysis indicated that the strength between the linear relationship between performance expectancy and self-management was correlated $r(42) .32, p < .05$, but the strength between the linear relationship between effort expectancy and self-management of learning was not correlated $r(42) .163, p = .291$.

The correlation analysis indicated a linear relationship between performance expectancy and behavioral intention. Additionally, the correlation analysis indicated a linear relationship between effort expectancy and behavioral intention. The survey results from the lack of correlation between SL and BI prevented it from predicting BI. The survey responses from the two focus groups were compared using ANOVA. This comparison showed no significant difference between the two focus groups survey responses (see Table 4.12).
Table 4.11  

*Bivariate Correlation of the Student Survey Responses and Exams*

<table>
<thead>
<tr>
<th></th>
<th>PE</th>
<th>EE</th>
<th>SL</th>
<th>BI</th>
<th>Inst. Method</th>
<th>Lecture Exam Avg</th>
<th>Lab Exam Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>.760**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>.320*</td>
<td>.163</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.034</td>
<td>.291</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>.800**</td>
<td>.766**</td>
<td>.143</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.000</td>
<td>.000</td>
<td>.355</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Instructional Method</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>.220</td>
<td>.157</td>
<td>.385**</td>
<td>.012</td>
<td></td>
<td></td>
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<tr>
<td>Mobile Group 2</td>
<td>.151</td>
<td>.308</td>
<td>.010</td>
<td>.938</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lecture Exam Avg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>-.090</td>
<td>-.195</td>
<td>.471**</td>
<td>-.133</td>
<td>.279</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.559</td>
<td>.204</td>
<td>.001</td>
<td>.391</td>
<td>.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lab Exam Avg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>-.072</td>
<td>-.099</td>
<td>.347*</td>
<td>-.120</td>
<td>.332*</td>
<td>.723**</td>
<td></td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.646</td>
<td>.526</td>
<td>.023</td>
<td>.445</td>
<td>.028</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td><strong>Combined Exam Avg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Mobile Group 1</td>
<td>-.050</td>
<td>-.112</td>
<td>.438**</td>
<td>-.144</td>
<td>.369*</td>
<td>.881**</td>
<td>.869**</td>
</tr>
<tr>
<td>Mobile Group 2</td>
<td>.746</td>
<td>.471</td>
<td>.003</td>
<td>.349</td>
<td>.013</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Note.* **p < .01. Correlation is significant at the.01 level (2-tailed). *p < .05. Correlation is significant at the .05 level (2-tailed). A significant correlation indicates a linear relationship. Performance expectancy (PE), effort expectancy (EE), self-management of Learning (SL), and behavioral intention (BI) are from the student survey. The instructional method was for Non-Mobile Group 1 and for Mobile Group 2.
Table 4.12

Analysis of Focus Group Participants

<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE1</td>
<td>19</td>
<td>1.997</td>
<td>.175</td>
</tr>
<tr>
<td>PE2</td>
<td>19</td>
<td>.236</td>
<td>.633</td>
</tr>
<tr>
<td>PE3</td>
<td>19</td>
<td>2.895</td>
<td>.106</td>
</tr>
<tr>
<td>PE4</td>
<td>19</td>
<td>1.482</td>
<td>.239</td>
</tr>
<tr>
<td>EE1</td>
<td>19</td>
<td>.065</td>
<td>.802</td>
</tr>
<tr>
<td>EE2</td>
<td>19</td>
<td>.362</td>
<td>.555</td>
</tr>
<tr>
<td>EE3</td>
<td>19</td>
<td>.257</td>
<td>.618</td>
</tr>
<tr>
<td>SL1</td>
<td>19</td>
<td>.634</td>
<td>.436</td>
</tr>
<tr>
<td>SL2</td>
<td>19</td>
<td>.007</td>
<td>.935</td>
</tr>
<tr>
<td>SL3:</td>
<td>19</td>
<td>2.725</td>
<td>.116</td>
</tr>
<tr>
<td>SL4</td>
<td>19</td>
<td>.832</td>
<td>.374</td>
</tr>
<tr>
<td>BI1</td>
<td>19</td>
<td>.171</td>
<td>.684</td>
</tr>
<tr>
<td>BI2</td>
<td>19</td>
<td>.109</td>
<td>.745</td>
</tr>
<tr>
<td>BI3</td>
<td>19</td>
<td>.007</td>
<td>.937</td>
</tr>
</tbody>
</table>

Note. The answers to the questions from each group were not statistically significantly different, $p < .05$. Performance Expectancy Questions 1 to 4 are represented by PE 1 to PE 4. Effort Expectancy Questions 1 to 6 are represented by EE1 to EE3. Self-Management Of Learning Questions 1 to 4 are represented by SL1 to SL4. Behavioral Intention Questions 1 to 3 are represented by BI1 to BI3.

The survey results indicated that the students in both the mobile group and the non-mobile group had similar performance expectancy and effort expectancy for mobile learning. The difference between the two groups was not statistically different. The combined score for performance expectancy was ($M = 5.49$), and this score ranked performance expectancy between somewhat agree and agree on the seven-point Likert scale. This data indicated that both groups believed that using mobile technology would be helpful in acquiring knowledge and / or getting better grades. Next, the survey had students rank their effort expectancy. The combined score for
effort expectancy was \((M = 5.75)\), and this score ranked effort expectancy between somewhat agree and agree. The data indicated that both groups believed that mobile technology for learning was easy. Additionally, the questions looked at the students' responses to questions about SL.

### 4.7.2 Self-Management Learning

SL was defined as the extent to which an individual believed he or she was self-disciplined and could learn on their own. The ANOVA analysis of the survey results for SL \(F(1,42) = 7.327, p = .010\) indicated that the groups ranked this part differently (see Table 4.13).

For example, students in the non-mobile group \((M = 4.80)\) ranked their ability to learn on their own between neutral to somewhat agree, and the students in the mobile group \((M = 5.5)\) ranked their ability to learn on their own between somewhat agree to agree.

<table>
<thead>
<tr>
<th>Table 4.13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grouped Survey Response Compared to Instructional Method by ANOVA</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>PE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>EE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SL</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>BI</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*Note.* Survey response scores for the mean \((M)\) were separated to show the difference between groups. \(^*p < .05.\)

The individual question analysis resulted in two questions that were statistically significantly different, see Table 4.14. The first question that the groups differed on was SL3: I am able to manage my study time effectively and easily complete assignments on time. The results \(F(1,42) = 8.032, p = .007\) indicated that the students in the non-mobile group \((M = 4.64)\)
and the students in the mobile group \((M = 5.59)\) ranked the question statistically significantly different. The mobile group ranked the question in the somewhat agree to agree part of the Likert scale, but the non-mobile group ranked this question between neutral and somewhat agree. The second question that the groups differed statistically was SL4: In my studies, I set goals and have a high degree of initiative. The results \(F(1,42) = 6.237, p = .017\) indicated that the students in the non-mobile group \((M = 5.14)\) and the students in the mobile group \((M = 5.86)\) ranked the question somewhat agree and agree respectively. The other two questions were not statistically significant (see Table 4.14).

Table 4.14

**SL Survey Responses Compared to Instructional Method by ANOVA**

<table>
<thead>
<tr>
<th>Self-Management of Learning</th>
<th>(F)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL1</td>
<td>3.046</td>
<td>.088</td>
</tr>
<tr>
<td>SL2</td>
<td>1.824</td>
<td>.184</td>
</tr>
<tr>
<td>SL3</td>
<td>8.032</td>
<td>.007*</td>
</tr>
<tr>
<td>SL4</td>
<td>6.237</td>
<td>.017*</td>
</tr>
</tbody>
</table>

*Note. Survey responses for SL compare to Instructional methods individual question analysis. *\(p < .05\). **\(p < .01\). SL1 - When it comes to learning and studying, I am a self-directed person. SL2 - In my studies, I am self-disciplined and find it easy to set aside reading and homework time. SL3 - I am able to manage my study time effectively and easily complete assignments on time. SL4 - In my studies, I set goals and have a high degree of initiative.*

The regression analysis of the student survey responses were divided into parts. The combined groups lecture exam averages were compared to the SL survey responses, see Figure 4.1. Additional analysis split the combined lecture exam averages by SL data into the two separate groups (see Figures 3 and 4). Then regression analysis was used to compare the two combined group lab exam averages and SL, see Figure 4.4. Next, the analysis split the combined lab exam averages by SL data into the two separate groups (see Figures 6 and 7). Regression analysis compared the combined lab and lecture overall exam averages and SL (see Figure 4.7).
**Figure 4.1.** Combined groups lecture exam average by SL. SL was ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.

**Figure 4.2.** Non-mobile group lecture exam average by SL. SL was ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.
Figure 4.3. Mobile group lecture exam average by sl. sl ranked on a likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.

Figure 4.4. Combined groups lab exams average by SL. SL ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.
Figure 4.5. Non-mobile group lab exam average by SL. SL was ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.

Figure 4.6. Mobile group lab exam average by SL. SL was ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.
Figure 4.7. Combined exams averaged by SL. SL was ranked on a Likert scale from strongly disagree (4) to disagree (8) to somewhat disagree (12) to neutral (16) to somewhat agree (20) to agree (24) to strongly agree (28). The scatterplot data with a fit line show a trend of student responses and lecture exam scores. The gray line that runs up from 16 on the x-axis represents the neutral part of the scale.

A regression analysis evaluated whether survey questions on SL were predictive of combined groups lecture exam average scores for students in this study. Linear regression analysis yielded a statistically significant effect, $F(1, 42) = 11.969, p = .001, r^2 = .22$, indicating that SL explained 22% of the variance in the combined two groups lecture exam average scores. This result indicated that the student survey responses to the SL questions were predictive of the combined lecture exam scores. The students in the mobile group ($M = 22.02$) ranked their ability to learn on their own higher than the non-mobile group ($M = 19.2$). The relationship was demonstrated by a scatterplot of the combined group results, see Figure 4.1.

To determine the relationship between Lecture Exam Average and SL, the two groups
were analyzed separately. The relationship demonstrated by a scatterplot of the non-mobile group by SL, see Figure 4.2. Then, the relationship demonstrated by a scatterplot of the mobile group by SL, see Figure 4.3. The bivariate correlation analysis of the non-mobile group indicated that the strength of the linear relationship between Lecture Exam Average and SL was not statistically significantly correlated, \( r(19) .149, p = .542. \)

The scatterplot of the non-mobile group data indicated that seven of the nineteen students responded that they could manage their own learning, but they scored 70 or lower on their lecture exam average score. Further analysis of the non-mobile group scatterplot data indicated that three of the nineteen students ranked the survey questions about their ability to manage their own learning between disagreed or somewhat disagree.

The mobile group was not correlated with Lecture Exam Average and SL \( r(21) .333, p = .140. \) The mobile group scatterplot data indicated that all of the students ranked the survey questions about their ability to manage their own learning between somewhat agree and strongly agree. Further analysis of the scatterplot of the mobile group data indicated that four of the twenty-one students responded that they could manage their own learning, but they scored 70 or lower on their lecture exam average score. The analysis of each group separately did not show a statistically significant linear relationship, but the analysis of the combined groups did show a strong linear relationship. This difference could be the result of the large number of students in the combined data.

A regression analysis was conducted to evaluate whether Self-management of learning (SL) was predictive of combined lab exam average scores. The regression analysis yielded a statistically significant effect, \( F(1, 42) = 5.601, p .023, r^2 = .12, \) indicating that SL explained 12% of the variance in the combined lab exam average scores. This result indicated that the
student survey responses to the SL questions were predictive of a small but significant amount of the lab exam scores. Again the students in the mobile group ($M = 22.02$) ranked their ability to learn on their own, higher than the non-mobile group ($M = 19.2$). The relationship was demonstrated by a scatterplot (see Figure 4.4 for the combined groups lab exams average scores by SL).

To determine the relationship between lab exam average and SL, the two groups were analyzed separately. The relationship was demonstrated by a scatterplot of the non-mobile group (see Figure 4.5 for the non-mobile group lab exam average and SL). The bivariate correlation analysis of the non-mobile group indicated that the strength of the linear relationship between Lab Exam Average and Self-management of learning was not statistically significantly correlated, $r(20) .112, p = .639$. The scatterplot of the non-mobile group data indicated that five of the twenty students responded that they could manage their own learning, but they scored 70 or lower on their lab exam average score. Further analysis of the non-mobile group scatterplot data indicated that three of the twenty students ranked the survey questions about their ability to manage their own learning between disagreed or somewhat disagree.

The relationship was demonstrated by a scatterplot of the mobile group (see Figure 4.6 for the mobile group lab exam average and SL). The mobile group was not correlated with lab exam average and SL $r(21) .316, p = .163$. The mobile group scatterplot data indicated that all of the students ranked the survey questions about their ability to manage their own learning between somewhat agree and strongly agree. Further analysis of the scatterplot of the mobile group data indicated that three of the twenty-one students responded that they could manage their own learning, but they scored 70 or lower on their lab exam average score. The analysis of each group separately did not show a statistically significant linear relationship, but the analysis of the
combined groups did show a strong linear relationship. This difference could be similar to the lecture results with the larger number of students in the combined data.

A regression analysis was conducted to evaluate whether self-management of learning (SL) was predictive of combined exam average scores. The regression analysis yielded a statistically significant effect, $F(1, 42) = 9.951, p = .004, r^2 = .19$, indicating that SL explained 19% of the variance in the combined exam average scores. The relationship was linear as demonstrated by a scatterplot of the two variables (see Figure 4.7 for the combined exam average and SL).

The bivariate correlation of the student survey responses and exams in Table 4.11 indicated that another possible independent variable SL may be effecting the dependent variable (exam scores). I used regression analysis to determine the effect of other possible independent variable shown by the bivariate correlation discussed above. Next, a linear regression analysis was used to compare the two possible independent variables, instructional method and SL, with the lab exam average scores. The regression analysis yielded a statistically significant effect, $F(1, 40) = 5.601, p = .007, r^2 = .219$. After separating SL and instructional method, the results indicated the score for the instructional method was statistically significant as compared to SL. The analysis indicated that instructional method, $t=2.247, p = 0.30$, was statistically a better predictor of lab test scores than SL, $t=1.511, p = 1.39$. This result was supported the by the separate analysis of lecture exams and lab exams for both the mobile group and non-mobile group. Other possible independent variables such as age, gender, racial-ethnic, marital, and current education level were compared in this study. The other variables were not found to have a statistically significant effect in this study.
4.8 Focus Group Interview Results

This section of the chapter contains the findings of the two focus groups interviews. The focus groups were students from both groups that volunteered to answer questions found in Appendix L. Code names were used to replace the actual names. The demographics of the 9 students from the mobile group included 5 men and 4 women. All of the focus group participants were under the age of 25 years old. They described themselves as 6 White Non–Hispanic, 1 African American, 1 Asian, and 1 Hispanic. The demographics of the 11 students in the non-mobile group included the following: 8 White, Non–Hispanic and 3 African Americans. All of the focus group participants were under the age of 25 years old. Additionally, the survey item analysis of the students in the two focus groups indicated they were statistically the same.

The answers to the Likert scale survey questions were similar for performance expectancy, effort expectancy, behavior intention, and self-management of learning for both focus groups. The descriptive statistics of the two focus groups survey responses and the ANOVA analysis are in Table 4.15. The two focus groups were compared with ANOVA. The results of the ANOVA comparison indicated no statistically significant differences from the survey responses by the two focus groups.

All of the answers and comments to the focus group questions were transcribed from audio recordings. Two researchers did the transcript analysis separately. We each used software to create codes from the answers and comments. Then we met online to discuss the transcript codes, and we grouped these into three main categories. The categories were named disadvantages, depends, and benefits. The category of disadvantages was supported by four themes in Table 4.16. The category of depends was supported by two themes in Table 4.17. The category of benefits was supported by three themes in Table 4.18.
<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>M</th>
<th>SD</th>
<th>df</th>
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<tr>
<td>PE1 I would find m-learning useful in my learning.</td>
<td>Non-Mobile Group 1 5.18 1.60 19 1.997 .175</td>
<td>Mobile Group 2 6.11 1.27</td>
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<td></td>
<td>Non-Mobile Group 1 5.09 1.64 19  .236 .633</td>
<td>Mobile Group 2 5.44 1.59</td>
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<td>PE2: Using m-learning would enable me to accomplish learning activities more quickly.</td>
<td>Non-Mobile Group 1 4.64 1.69 19 2.895 .106</td>
<td>Mobile Group 2 5.78 1.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Mobile Group 1 4.36 1.80 19 1.482 .239</td>
<td>Mobile Group 2 5.33 1.73</td>
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<td></td>
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<tr>
<td>PE3: Using m-learning would increase my learning productivity.</td>
<td>Non-Mobile Group 1 5.27 1.19 19 .362 .555</td>
<td>Mobile Group 2 5.67 1.73</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Non-Mobile Group 1 5.36 1.36 19 .362 .802</td>
<td>Mobile Group 2 5.33 2.01</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PE4: If I use m-learning, I will increase my chances of getting a better grade in class.</td>
<td>Non-Mobile Group 1 5.11 1.35 19 .257 .618</td>
<td>Mobile Group 2 4.73 1.35</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Non-Mobile Group 1 5.78 1.21 19 .364 .436</td>
<td>Mobile Group 2 5.36 1.09</td>
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<td></td>
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<tr>
<td>EE1: It would be easy for me to become skillful at using m-learning.</td>
<td>Non-Mobile Group 1 4.27 1.35 19 .007 .935</td>
<td>Mobile Group 2 4.22 1.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Mobile Group 1 4.36 1.12 19 2.725 .116</td>
<td>Mobile Group 2 5.22 1.20</td>
<td></td>
<td></td>
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<tr>
<td>EE2: I would find m-learning easy to use.</td>
<td>Non-Mobile Group 1 5.09 1.04 19 .832 .374</td>
<td>Mobile Group 2 5.56 1.24</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EE3: Learning to operate m-learning is easy for me.</td>
<td>Non-Mobile Group 1 5.27  .91 19 .007 .937</td>
<td>Mobile Group 2 5.33 2.29</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SL1: When it comes to learning and studying, I am a self-directed person.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
<td></td>
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<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL2: In my studies, I am self-disciplined and find it easy to set aside reading and homework time.</td>
<td>Non-Mobile Group 1 5.27  .91 19 .007 .937</td>
<td>Mobile Group 2 5.33 2.29</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL3: I am able to manage my study time effectively and easily complete assignments on time.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL4: In my studies, I set goals and have a high degree of initiative.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI1: I intend to use m-learning in the future.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI2: I predict I would use m-learning in the future.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI3: If available, I plan to use m-learning in the future.</td>
<td>Non-Mobile Group 1 5.00 1.48 19 .171 .684</td>
<td>Mobile Group 2 5.53 2.12</td>
<td></td>
<td></td>
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<td>Non-Mobile Group 1 5.45 .69 19 .109 .745</td>
<td>Mobile Group 2 5.67 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Performance Expectancy Questions 1 to 4 are represented by PE 1 to PE 4. Effort Expectancy Questions 1 to 3 are represented by EE1 to EE3. Self-Management of Learning Questions 1 to 4 were represented by SL1 to SL4. Behavioral Intention Questions 1 to 3 are represented by BI1 to BI3. The instructional method was for Non-Mobile Group 1 and for Mobile Group 2. The students were told that m-learning was mobile learning.
### Table 4.16

**Themes of Disadvantages**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Definitions</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction</td>
<td>Refers to mobile technology distracting students from learning.</td>
<td>6</td>
</tr>
<tr>
<td>Effort</td>
<td>The students’ answers to how mobile technology will affect their effort to learn.</td>
<td>3</td>
</tr>
<tr>
<td>Book Preference</td>
<td>The student preference for of books over technology for learning.</td>
<td>5</td>
</tr>
<tr>
<td>Technology Deficiency</td>
<td>Defines all the different issues from learning with mobile technology.</td>
<td>11</td>
</tr>
</tbody>
</table>

### Table 4.17

**Themes of Depends**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Definitions</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>Refers to the course described by the student.</td>
<td>9</td>
</tr>
<tr>
<td>Personal Preference</td>
<td>Refers to the student’s preference.</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 4.18

**Themes of Benefits**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Definition</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>Students learning with mobile technology.</td>
<td>12</td>
</tr>
<tr>
<td>Adapting to Change</td>
<td>Students discussing the need to adapt teaching and learning to keep up with change.</td>
<td>5</td>
</tr>
<tr>
<td>Mobile Learning</td>
<td>The personal preference for using mobile technology for learning.</td>
<td>4</td>
</tr>
</tbody>
</table>
4.8.1 Focus Group Result Themes

The focus group data also provided answers to the challenges part of the research question. These answers and comments came from the students that were in both focus groups. The category of Disadvantages was supported by several themes that included: distraction, effort, book preference, and technology deficiency. As shown in Table 3.23, the theme called technology deficiency had the highest number of occurrences. The next two themes were distraction and prefer books. Then the effort theme had the least number of occurrences.

Two themes supported the category of Depends. These two themes were called subject and personal preference. As shown in Table 3.24, the theme called subject had the highest number of occurrences.

The focus group interviews resulted in four themes under the category of Benefits. As shown in Table 3.25, the theme called learning had the highest number of occurrences. Then theme called adapting to change was next. The mobile learning preference theme had the least number of occurrences.

4.8.2 Focus Group Themes

The categories were named disadvantages, depends, and benefits. The category of disadvantages was supported by four themes. The focus groups comments were divided between the mobile group and non-mobile group. The mobile group had the majority of the comments on almost every question. Their hands-on use of the technology provided them the experience to make comments with specific examples. The focus groups were asked the following: What are the possible challenges you could encounter in learning using mobile technology? The technology deficiency theme came from the technical challenges and issues that students
described during the focus group interviews. Technology deficiency was the term that defined all the different technology issues from learning with mobile technology. The mobile group had the majority of the comments about technology deficiencies because these students had hands-on experience.

Allie commented about challenges with quizzes on her mobile device in lecture.

Allie: A lot of the time when we are in lab or in here. He want use to take a quiz. The quiz does not work. So, I cannot submit my quiz. I do not get any grade for that or I do not get credit for what I am trying to do. That is my big thing. A lot of the time there are glitches. There are glitches with everything you use in technology.

Another student had a similar problem using her smartphone and the QR Code Reader. For example, Nadine said, “Last semester the format was different in the QR Reader. I could not see the whole thing and sometimes it would not come up on the phone.” Nadine and I tried several times last semester to get her smartphone to scan the QR Code so she could participate using her device. She used the instructor provided device to complete the activities. Additionally, two other students agreed that not being able to submit answers or participate in the activities were challenges. Tanner said, “And like she said earlier, not being able to submit the activity. I’ve had that problem a couple of times.” In another example, Chris agreed with both of these comments. Chris said, “I mean those are some possible challenges with mobile technology. Not sending. Not working. Say the internet is down on your phone, something is broken. Those are challenges.” These technology deficiencies were frustrating for Tanner, Nadine, and Allie because they wanted the activities and quizzes on their mobile device.

These glitches would make Allie very upset because she was the only one in her lab group that regularly had a submission problem. After I let her use my phone to submit the quiz, she was able to get it to work. All three students that had technology issues with submitting quizzes or completing activities had additional access to the activities by using an instructor
provided device. This issue remained a problem until I was able to change the settings on the Google form used for quiz submission. Another technology issue was trying to read on the small screen.

Macy said the following:

Like when he gives us a link to paragraph three. I rather look at the book. I rather the links go to video, pictures, and stuff like that. I focus more on that stuff, than on my book. I already have a book. Why am I going to go on like a phone and read a whole paragraph? I could just read my book. I am for video and pictures.

Several students in the focus group agreed to this issue. Chris said the following:

If you are going to use mobile technology to make it easier to learn, then you should make the effort to focus more on what you are trying to learn. Instead of trying to have everything like a normal book, you should make it more concise.

Both Chris and Macy were strong supporters of mobile learning that made their lives easier, but they did not want to try to read something on the small screen of a smartphone that was already in their book.

Continuing with technology deficiency theme there were several technical issues that students in the non-mobile group described during the focus group interviews. The most common technical issues were device specific. The first technology issue was from Samantha. She said, “I would not know how to work it.” The lack of experience that students have using mobile technology for learning was discussed in a study by Frohberg et al. (2009). Frohberg et al (2009) described how mobile technology-based activities can be designed with scaffolding. John and Madalyn were concerned that their mobile devices would lose power in the middle of an activity, or the battery would die. These same concerns were discussed by Franklin (2011). The need to have adequate power must not be overlooked by someone using mobile technology. A solution would be access to an extra charging stations and wireless networks infrastructure that will require investment by the institution. One of the students talked about working with other
students online or with FaceTime. FaceTime is an Apple communication app that allows you to make video calls over wireless networks (Apple Corporation iOS, 2013). This app was limited to one manufacture of mobile devices and would not be accessible by every student.

For example, Sadie asked, “What if you don’t have FaceTime.” The exchange about this app between Sadie and John continued with John saying, “If everybody had mobile technology for learning, you would have to have FaceTime. It would be implied."

These technology issues could be corrected. The cost of mobile devices and smartphones for some students will prevent them from being able to provide their own technology. Lidia said, “Some people don’t have smartphones.” This was a real disadvantage for some students, but I was able to provide about ten devices for students that did not have their own technology. All of these devices were from my institution. The possible loss of your mobile device could happen. Barbara said, “It’s kind of overwhelming. What if something happens to your phone?” She was in the focus group that did not use their phones over the semester. The students in the mobile group understood the basic lab safety issues regarding using their mobile device. Another example of a technology deficiency issue that concerned Samantha was the cost of using her data. She had just lost her job, and she did not want the added cost of using her data plan on her smartphone. The solution for both laboratory and classroom mobile technology-based activities would require adequate high speed wireless internet access.

The book preference theme resulted from responses that described a preference for using books to learn. Book preference was the term that defined student preference for a book over technology for learning. A few of the students from the mobile group preferred learning from a book. For example, Kelly said, “As a student, I learn better opening a book, studying and stuff.” He had two reasons for favoring a book over mobile learning. One reason was concern over
technology problems. Kelly said, “I don’t want my phone call to get dropped, just like I don’t want my internet to get dropped, while I am doing this quiz on a computer. So, what I need is a book.” Another reason Kelly wanted a book instead of mobile technology was distraction. Allie also preferred a book because she knew she would be distracted.

Allie commented on distraction:

I have a tendency to go to Dillards.com and buy things I do not need. And that is what I would end up doing. And so for me it is easier to have a paper study guide and to look in the book and find the answers. Because that is the only way, I will actually sit down and do it.

A few of the students describe how the internet could be confusing because of the multiple answers online. These students preferred a book over mobile technology. Jill said, “You are looking up answers on the internet. It may not have been the answer your professor wanted. Whereas the book is like, this is the answer that is going to be on the test.” Tanner added, “Word for Word.” Tanner was describing the answer in the book matching the answer on the test.

Students from the non-mobile group also had answers related to book preference. For instance, Cade said, “I am just old fashion. Hey, I am good with a book.” Cade’s answer to this question is his honest opinion, but he never purchased a textbook for class. He would have to look on with another student in class or just sit and not participate. He did buy a lab manual that he would bring to lecture and lab. He told me that he did not want to pay the high cost for a textbook. Next, a discussion about using the dictionary to look up words came up in both focus groups. Kelly described why he preferred the dictionary:

Say I asked the teacher what a certain word means. Well the teacher will tell me to look it up in the dictionary. It actually helps me to remember it more doing it the manual way, as opposed to Googling it, or somebody just telling me the answer. You know. Actually doing the work, it actually stays with me.

One of the students in the non-mobile group suggested you could look up the meaning of
words while reading on the Kindle. The reply from another student was use a dictionary. Barbara said, “You just want to go to dictionary.com, or you just want to go find a dictionary and look up the word. I think it just depends on your preference.”

The distraction theme referred to mobile technology distracting students from learning. According to the mobile group, social media such as Facebook, Twitter, Pinterest, and Instagram could be a distraction. Two students said they did not want to do anything boring. They just wanted to get on Facebook and see what their friends are doing. Several others students said they would be distracted by having access to their mobile device in class or lab. For instance, Allie said, “For me, it goes back to the distraction. I am one of those easily distracted people.” To have one click away access to social media for some students may just be too tempting. She continued:

So, if you were to say get online and go to this website and take this test, and that is going to be your study guide for this test. Just in all honesty, I do not think I can do it. I would click on a new tab and go to Facebook or I would go to whatever I could get on. This student could not even study for a test with technology because the temptation to access social media would be too strong. Another student said he would also be too tempted to click on Facebook instead of learning. Bob said, “You can go to that (Facebook) with one click of a button.” The distraction from social media may be difficult for some students to overcome. There were technological solutions that could limit access to social media, but these would not be effective on students that have cellular data plans. Other distractions that the students said they would click on instead of focusing on the activities included the following: videos, messaging friends, online shopping, and porn.

According to the non-mobile group, social media such as Facebook, Twitter, Pinterest, and Instagram could be a distraction. When asked about using mobile technology to study
several said they would be distracted. For example, Madalyn said, “If I was trying to do homework on my computer. I would open up another tab, and I would be on Facebook, Twitter, and Pinterest.”

The effort theme was the term that defined all the student answers to how mobile technology would negatively affect their effort to learn. The negative effort comments ranged from lazy to hassle. The students in both focus groups were asked if using mobile technology would change their effort in other classes. All of the students that indicated that mobile technology would negatively influence their effort were in the non-mobile group. Madalyn said, “It might make me lazy because I could easily look anything up.” This was reinforced by the answer from Sadie. Sadie said, “Yeah, I would be lazy.” Another example of mobile technology affecting student effort was from Cade. Cade discussed how the online e-journal last semester negatively affected his effort:

It was Stowe’s online e-journal last semester. It did not help at all. It just gave me a bad grade. I did not have the time to do them. They were too much of a hassle. We had to take pictures. Like I used Google something to make a webpage, and I complained to him (Stowe) constantly about it. And he got rid of it this semester. I am happy about that.

Cade's effort on the assignment last semester was almost none, but he did put a lot of effort into complaining.

The category of depends had several answers from the focus groups that were not clearly in either the category of benefits or category of disadvantages. The category of depends was supported by the subject theme and the personal preference theme. The subject theme was used because the students referenced particular subjects when they answered about mobile technology affecting their effort in other classes. Several of the students in the mobile group indicated that using mobile technology would change their effort for math. For instance, Allie said “I think MyMathLab is what helped me the most. I could replay the video and she (teacher) would replay
(this is the first step); this is how you get the answer”. In another instance, Bob said, “I personally learn more from MyMathLab. That is because I can go to view the example and go to the part I had trouble with. It is piece by piece.” However, the use of MyMathLab software did not work for every math student. For example, one of the students had difficulty learning math online. Jill said, “I know I’ve had teachers that do the online math book, and I can’t learn that way in math. I have to have someone at a board show me how to do it.” To these students their effort was dependent on their preference for using MyMathLab software.

History was the next subject that the students used as an example. Several of them discussed how they could use mobile technology to learn history. For example, Kelly liked seeing the history facts as an animated presentation. In another example, Jill commented on how using mobile technology depended on the subject:

I think it depends on the subject as well, because, like for example, like me with history. I have learned more from like nerding out over the history channel and national geographic, than I have ever learned from a teacher lecturing me. It is that class.

Conversely, there were students that would rather just be told what happened on this date in history. For instance, Allie said, “For me it is easier for someone to tell me, this is what happened, on this date. I can write it down and remember it.” To these students in the mobile group, the using mobile technology would either positively or negatively affect their effort for history. Kelly said, “That mobile technology could make English easier for him. The subject is a big thing. Because if there was an English website to help me write my paper. I could also use a website that helped me to write poems.” Another question asked if the students have used mobile technology to learn in the past?

English literature was brought up again by Nadine.

I was in English literature, and I had to read a book in Middle English. So, I went to Sparknotes.com, and they translated into English I could understand. The internet has
many resources that you can use and it is really helpful.

The interviewer asked, “What is Sparknotes?” Kelly replied, “It is a website, where it
summarizes the chapter. It’s kind of like Cliff Notes back in your day.” The students used the
Sparknotes.com website to keep from buying and actually reading their books.

In the non-mobile group, students indicated that using mobile technology would affect
their effort in English. Darlene gave examples of ways mobile technology could make learning
English easier. Darlene said, “Like for English it could be good. Because I could highlight like
on the Kindle. It could help you on your reading.” The contrary opinion about using mobile
technology for English came from Samantha. She said, “I would need a reason for English.”

When the students answered the question about mobile technology changing their effort
in class. Their answers resulted in the personal preference theme. The personal preference theme
was supported because the students talked about personal beliefs and feelings toward using the
technology. The personal opinions of both Chris and Macy from the mobile group were very
strong. First, Chris really believes that mobile technology would improve his effort in other
classes:

I personally believe so. If some of its lecture and you go on to do some mobile
technology it gives you some variety and some kind of variation between what you are
doing. So you stay focused on what you are doing. Like say they talk for 30 minutes, you
stay wake for that, you know what is going on. And alright, look over this diagram, fill in
some questions, and then get back to me and have a grade. You are no longer just paying
attention to what they are saying. You are doing the exercise. So you actually feel more
into the lecture.

This was a very strong answer that covered how mobile technology could be used to improve
student’s effort in classes besides biology. However, another student in this focus group had a
negative personal experience with mobile learning. According to Macy, she was in an online
class that just put the entire book online. For instance, Macy said. “I did the whole mobile
learning thing, but I feel like they approached it in a different way. And it didn’t help me, what so ever.” The interviewer asked how did the teacher in that class approach it. Macy said, “It would be the same thing as reading the textbook. It was not anything different. It was just a book on there, a book on the computer. It was boring. I hated it.” Macy had a very bad experience with mobile learning, but she indicated that she was a regular user of mobile technology for learning in biology. These two different examples were both very specific personal opinions about using mobile technology for learning. According to Chris, “I guess what it boils down to is that each subject is different and each person is different, each approach has to be different.” The comments of Chris could be used as a guide for future mobile learning, where the teacher used mobile technology to personalize instruction to the students.

The focus group interviews resulted in four themes under the category of Benefits. The learning theme had the highest number of occurrences. Then adapting to change theme was next. The mobile learning preference theme had the least number of occurrences.

The question asked the focus groups what were the possible benefits of using mobile technology for learning. Their answers resulted in the learning theme. The learning theme was defined as student learning with mobile technology. Learning style was part of several answers that supported the learning theme. Visual learning style was described the most. Students in mobile groups described how mobile technology could help them with videos and images of the content. Jill made the following comment about learning style:

It covers all your bases. Because many people are visual learners and many people are audio learners. So I mean. If you use the computer, you get the visual like you would in a book. He also is up there giving us a PowerPoint presentation, so it covers all like your bases. And then some people are more like hands-on learners, so if you are doing the thing on the phone or the computer you get more out of it, than just reading the book.

Jill’s answer directly related to her eye condition. She needs to see the images enlarged or up
close, so she is an auditory learner. The videos or images with audio were her preference. In another example, Nadine and Kelly liked using the mobile technology-based activity in lab to learn the rat anatomy during dissection. Kelly said, “When we dissected the rat, there was a thing on the QR Reader and the rat was already dissected, and we went through and we identified the organs that were inside of the rat. So that did help me.” The students were able to use the mobile technology-based activity over the dissection to aid them in identifying the organs. Next, when the students were asked the following question: How could you use mobile technology to learn in this class or lab? The students in the mobile group all wanted more videos to help them learn the content. Chris said, “We had the QR Readers, which pull up pictures. Fill in the blanks, videos, links to different websites with a plethora of information. I feel the videos and the actual diagrams are the easiest to understand.” This answer was agreed to by all of the participants in this focus group. In an outside of the class example, Macy used the videos to follow up on questions that she did not get to ask because class ran out of time:

Like, I mean, so far it has helped me. It has not really affected me. OH! Sometimes, when you are in the classroom, you want to ask a question, but he (Mr. Stowe) only has a certain amount of time to cover the material. And the video he provides and the stuff like that. I can rewind it. I can replay it, and answer all my questions.

In another outside of the classroom example was used to answer the following question: How could you use mobile technology to learn in this class or lab? Nadine described her experience last semester using a website and blog to help study:

Like last semester, we had a website to create and blog in. And then we took pictures of everything. We had it all on the website, so we could go back and look at it. And we wrote descriptions of what we did during the last period. And I think that really helped because people forget and when you can go back and see what you did. I think that was really helpful.

After this experience last semester, Nadine told me she took pictures with her smartphone in every class to help her remember what was covered. Chris used his experience last semester in
the environmental class to help him answer the following question: If you have used mobile technology to learn in the past, when and how did you use it?

I had another one of Mr. Stowe’s classes, environmental science class, and we met three times at the park here in Longview over on Highway 80. We actually did a study of the water. There is a creek there. At first everyone on the first visit there, they had books, paper, and stuff. Thinking they would need that, but he is like no, here is a QR Code. All the information you need to out in is on here. And you just figure it out and enter the data. Discuss and leave. We were there for an hour and a half, the first time. The second time, almost no one was carrying anything unnecessary. They all had their phones, they left all that stuff. They carried a piece of paper and a pen. Just so they could jot down what they needed, so they could remember it. We did what we needed to do, it was very efficient and we were gone in 30 minutes.

Chris really liked how efficient the process was to learn the fieldwork procedures and submit results using his smartphone:

I prefer honestly going on the website through mobile technology mostly because I feel as we have done that. What we have been trying to learn has been very short and concise. There is no filler. No information that we did not need to know. It was all right there. It was exactly what we were covering. If we had to fill in the blanks, all of it was there. You just had to look for it.

Then he added, “Whereas in the book, I mean a lot of classes, Oh here’s a $120 book, and we are going to do three chapters out of it.” Other students agreed with Chris about the book, they did not want to spend over a hundred dollars for a textbook and not use it for class.

The next part covered the answers about participating in mobile learning from multiple locations. These included studying on your lunch break and completing quizzes from your smartphone. This first example came from Jill. She works a fulltime job, and she regularly uses her smartphone to study on her 30 minute lunch break. She said:

Oh, I forgot to study the chapter, and I have a test tomorrow. Well you have 30 minutes, and you have your phone. Your book is at home. You forgot about it. You always have or I at least always have my phone with me. Whereas my books like stays in my closet.

She was able to use her mobile technology to study because she always has her smartphone. The second example came from Bob. He was on a road trip for Spring Break in Florida. He used his
smartphone to take a quiz from the car.

The learning theme was defined as student learning with mobile technology. The non-mobile group did not have as many examples as the mobile group. The non-mobile group answers described how mobile technology would make learning more efficient, easier, faster, and convenient. For example, Lidia said, “You can share answers easier.” Another student said, “I could easily look anything up.” Several students answered in another way, they describe how this technology can help learning by providing access to broader range of ideas and information. Students could use mobile technology to meet online. Samantha said, “You could have a study group, and everybody could be at different places and meet all at once.” John called this a FaceTime study group.

The adapting to change theme was defined as the need to adapt teaching and learning to keep up with changing technology. The student answers that supported using mobile technology to adapt to change included: times are changing and the technology is here to stay. Mobile devices were cheaper for students to buy than laptops, and students are going to have to know how to use this technology in the workforce. The students were asked, what were the possible benefits of using mobile technology for learning? Macy said, “I think it benefits me as well, because outside of the classroom, we are constantly on YouTube, Facebook, Twitter, and everything. Times are changing, times will change. I think starting to use technology, now will help.” Chris agreed with Macy about the benefits of mobile technology and the need to adapt to change, and answered the following:

I agree with that. I also agree with the point that times are changing and as we develop more technology, we must use it more. I mean, most of us here in this room, we have grown up having cellphones. We grew up having computers. We learned the in and out of them. Were a little more personal when it comes to technology, than people of the older generation and that is just going to keep progressing as more and more technology comes out. And it is really helpful with mobile learning, because let say you have a busy life and
do not have the time to come into a classroom and learn in a classroom environment. With mobile learning, you could be home on a computer, you could be on your lunch break at work and be on your phone reading material and answering questions. You can get an education outside of just four walls.

Chris describes how his generation has grown up with technology, and that mobile technology has progressed to allow you to learn from anywhere.

Jill supported the need to adapt to change. She believed that eventually mobile technology would make textbooks and education cheaper for the student. For example, several students in the focus group did not understand why they were asked to buy a textbook. When the instructor only used a few chapters out of it in class. They did not want to spend their money on a textbook that would only be used a few times in class. Jill said:

I think eventually, if we could go to mobile learning, like as a permanent thing. It would be so much cheaper for like college students. Because you already have your iPhone or whatever, I mean you already paid for your internet access. Like you know, we are not going to pay like $120 for a book that we are going to read one chapter out of.

Moreover, students in both focus groups talked about the need to use technology in the workforce. Some students already know that certain careers required mobile technology as a normal part of the daily routine. Nadine had this to say:

I think online is the future. I think we are going to have to use it. When we go into the workforce, we are going to have to use an iPad. Even at the hospital and stuff, they use iPads and everything. And you are going to have to know it.

Her experience with mobile technology in the workplace comes from her family that is in the medical field. Her father is a doctor and he uses an iPad at the hospital.

Another comments that supported the adapting to change theme came from Allie. She was from the mobile group. Allie said, “Yeah, It relates better to us as teenagers.” She was describing the reason she wanted to keep using mobile technology in class. This student always
had her tablet and smartphone for class, but she admitted that she needs to use her book to study because of distraction.

The mobile learning preference theme was defined as a preference for using mobile technology for learning. Mobile learning preference was supported by students that liked the hands-on part of using mobile technology for learning. These students in the mobile group like the hands-on experience of using their device, and the change of pace in the lab and lecture helped to keep them engaged and awake. Bob said:

I like how you mix it up in the class. Like in here he will be lecturing and the next thing you know he will have us pull out our phones. I was half asleep and now I am wide awake. Then, I am like oh crap. I need to awake up and do something.

Additionally, the support for hands-on learning also came from Tanner, Jill, and Chris. When asked if using mobile technology changed your effort, Chris said:

I personally believe so. Because I have had classes where the teacher sat up there lecturing for 30 to 90 minutes, however long class is. And it starts to go into a drone and starts to get monotone, I stop paying attention. I just start wondering when I get to leave or do something else. If some of its lecture and you go on to do some mobile technology it gives you some variety and some kind of variation between what you are doing. So you stay focused on what you are doing. Like say they talk for 30 minutes, you stay awake for that, you know what is going on. And alright, look over this diagram, fill in some questions, and then get back to me and have a grade. You are no longer just paying attention to what they are saying. You are doing the exercise.

Tanner followed up with Chris’s answer by saying, “Hands-on.” Chris replied, “Yeah hands-on. So you actually feel more into the lecture.” In these examples, the students were motivated to participate in their own hands-on learning. They did not want to just sit and listen to a monotone lecture until they fell asleep. All of the students from the mobile group wanted to be engaged in their learning.

In the non-mobile group, Madalyn described her mobile learning preference. She described how she enjoyed using her mobile devices, and she thought other people would enjoy
using them for learning. Madalyn was in the focus group that had never used mobile technology for learning, but she used her smartphone all day.

4.8.3 Relation of Benefits and Disadvantages to Students’ Experiences of Mobile Technology-Based Activities

Each of the three categories either did show how the students (mobile group) used mobile technology for learning, or how they (non-mobile group) could possibly be affected if they used this technology in the future. The focus group data provided answers to the research question: What benefits and challenges did students encounter in their learning during the mobile technology-based activities? The majority of these answers and comments came from the students that were in the mobile group. The students in the mobile group had both answers and specific examples for the questions asked by the interviewer. The non-mobile group did not have as descriptive answers or comments as the other group. The category of Benefits was supported by the learning theme, adapting to change theme, and mobile learning preference theme. The learning theme was supported from students in the mobile group that have had positive experience learning with mobile technology-based activities. The mobile technology-based activities that benefited the students the most were the activities stored in their mobile devices. Student could open these activities up when they had a few minutes to study during the day. QR Codes provided an easy way to provide students these activities. Additionally, these students used their mobile devices to make videos, pictures, and record class discussion before exams. The mobile group (focus group) wanted the institution and instructors to start adapting to the changes in instructional technology. This required the institution to support their learning with additional wireless infrastructure. The students wanted their instructors to stop lecturing and start using the technology to engage them in learning. They really wanted to do more in class than just
sitting in their chairs trying not to fall asleep. The students that wanted to start using their mobile technology in all their classes had a mobile learning preference. For several of the students, the benefit was personal for using mobile learning. Some of these students in mobile group (focus group) used their mobile devices to study and take online quizzes. Most of them said they used their mobile device because it was efficient and easy. The reason several students answered that mobile technology-based activities benefited their learning was convenience. They always had their mobile device with them at all times.

The category of disadvantages was supported by four themes that included: technology deficiency theme, book preference theme, distraction theme, and effort theme. Technology deficiency theme was the term that defined all the different technology issues from learning with mobile technology-based activities. These technology deficiencies were frustrating for the students trying to do the activities. The students wanted to be able to do the activities and quizzes on their mobile device. The technology “glitches” were a direct disadvantage for students trying to learn using mobile technology-based activities. These students told me that it was not fair because they could not access or read the activities on their devices. They did not like using one of the instructor provided devices. After the glitches that affected the activities was identified and corrected, these students were able to use the activities. The book preference Theme that came from the students in the Mobile group was the result of these students understanding their own limitations for distraction. Both Allie and Kelly were distracted by easy access to social media on these devices. Distraction theme came from several comments about multimedia and social media distractions on the student own device. Several of these students in the focus group said they would be distracted by mobile technology-based activities because of the convenient access to other media. The effort theme was negative for most of the answers from the students.
in the non-mobile group. Some of these students said they would be lazy with mobile technology-based activities. Some of them said “I could use Google to find the answers.”

4.9 Summary of Results

Summary of data assessments looked at the effect the instructional method for the mobile group that used mobile technology-based activities and the non-mobile group that used handouts had on exam scores. The exam scores between the two groups were affected by the use of mobile technology-based activities. There was no statistically significant difference between the two groups in lecture quizzes or exams. The mobile group did have a statistically significant difference in lab exams exam scores as compared to the non-mobile group. Eta-squared for the three lab exams indicated that the independent variable (instructional method) could explain about eighteen percent of the variance in the dependent variable (exam scores). There were no statistical differences between the quiz scores between the groups. The combined lecture and lab exam comparison between instructional method and the combined lab exam and lecture exam average scores indicated a statistically significant difference. The mobile group combined lab exam and lecture exam scores averaged over eight points higher than the non-mobile group.

The survey asked the two groups their opinion on mobile learning. The questions were about using mobile technology and their performance expectancy, effort expectancy, behavior intention and self-management of learning. Prior research with business students by Lowenthal (2013) indicated that performance expectancy, effort expectancy, and self-management of learning predicted behavior intention. That was not the case with the biology students in this study. Their survey responses for SL did not correlate with effort expectancy or behavioral intention to use mobile technology for learning. The survey responses for self-management of
learning did correlate to exam scores. The survey responses from SL were compared to lab exams, lecture exams, and combined exam scores. The results indicated that the student responses for SL were predictive of lecture exam and combined exams, but the regression analysis for lab exams indicated that student responses for SL were not as predictive as instructional method. Additionally, the data assessment looked at other possible independent variables that statistically significantly affected the dependent variable. Regression analysis indicated that none of the other possible independent variables compared were statistically significant in this study.

Analysis of the focus groups resulted in three categories that were named Disadvantages, Depends, and Benefits. The category of Disadvantages was supported by four themes. The largest theme was called technology deficiency. Technology deficiency theme defined all the different technology issues from learning with mobile technology. Some of these issues discussed by the students did affect the students in class and the others were possible issues. For example, the mobile group had specific issues with technical problems that prevented them from accessing the activity. The lack of adequate access inhibited student learning. The non-mobile group had examples of technology deficiencies that were about the device. These issues included: cost, battery, loss or no access to a device, and not understanding how to use the device. The next largest was distraction. The distraction theme referred to mobile technology distracting students from learning. Many of the students in the mobile group described how easy access to social media (Facebook) on their mobile technology was distracting. Other distractions that this group described included: videos, messaging friends, online shopping, and porn. The non-mobile group also described how they would be distracted by social media. One of the students described the easy one click access to Facebook as being tempting. The student in the
mobile group had a book preference because of concerns over technical problems and
distraction. Two of the students in this group wanted to use a book because they were easily
distracted by social media. In the non-mobile group, the student’s comments about preferring a
textbook were his personal preference. He liked using a book instead of using technology. The
effort theme was used to define all the student answers that described how mobile technology
would negatively change their effort to learn. All of the students that indicated that mobile
technology would negatively influence their effort were in the non-mobile group. They said
using mobile technology might make them lazy because they could easily look anything up.

The category of Depends was supported by two themes. The subject theme was used
because the students referenced particular subjects describing how using mobile technology
would change their effort in other classes. Students in the mobile group indicated that using
mobile technology would change their effort for math, history, and English. All three subjects
were discussed by these students with both positive and negative results after using technology in
these subjects to support their learning. The non-mobile group discussed using mobile
technology for English class. One of the students described using her device to help her read, but
another student said she would need a reason to use mobile technology in English.

The personal preference theme was used because the students talked about personal
beliefs and feelings toward using the technology to change their effort in class. A student in the
mobile group described how mobile technology-based activities could be used in his other
classes for engagement. He described how the activities could be used to quiz students over a
short lecture, and the mobile activities would help keep him from falling asleep in class. In a
negative example, the student described a class that had the entire book on the course
management system. She did not like reading from her smartphone. A textbook would have been easier to read than her smartphone.

The category of Benefits was supported by three themes. Learning was the largest theme. It was defined as students learning with mobile technology. The students in the mobile group described the mobile technology-based benefits as being able to help students with different learning styles. These students wanted to see more videos and images about the course content. Mobile technology was described as convenient and efficient for learning. A couple of the students liked the convenience of accessing the activities from their devices on their lunch breaks at work. They always have their smartphones with them, but they do not carry around their books. For example, one of the students used his smartphone to access an online quiz while riding in the car on spring break. The short activities were liked because of efficiency. The student said the activities did not have unnecessary information. The non-mobile group described using mobile technology to look up information, meet online, and as a source of a broader range of ideas. After the learning theme, the theme with the most occurrences was called adapting to change. This theme was only from the students in the mobile group. These students discussed the need to adapt teaching and learning to keep up with the changing times and technology. Students in the mobile group wanted their teachers and the institution to change because the technology was here to stay. Another reason to adapt to changing technology was the need to know how to use this technology in the workforce. The last theme was called mobile learning preference. These students in the mobile group like the hands-on experience using their device, and the change of pace in the lab and lecture helped to keep them engaged and awake. In the non-mobile group, only one student described her mobile learning preference. She described how she
enjoyed using her mobile devices, and she thought other people would enjoy using them for learning.

The students in the mobile group used the mobile technology-based activities to improve their lab exams scores over the non-mobile group using handouts. The survey item analysis indicated that both groups were statistically the same in their opinion of performance and effort expectancy, but the mobile group ranked their ability to manage their own learning higher than the non-mobile group. Self-management of learning was a predictor of lecture exam scores, but it was not a significant predictor of lab exams scores. The themes from the data provided by the two focus groups answered the research question about the benefits and challenges that students encounter with mobile technology-based activities. The students using mobile technology in the class and lab had specific and detailed answers. non-mobile group provided a more open prospective of the possible problems from using mobile technology for learning. mobile group spoke more favorably towards mobile technology-based learning than the Non mobile group, especially in learning, adapting to change, and mobile learning preferences.
CHAPTER 5
DISCUSSION

5.1 Introduction

Chapter 5 has four main parts. The first part covers the discussion of findings of the study. These include the lecture, lab, survey data, and focus group analysis. The second part of the chapter includes the implications of this study. These include institutional implications that could affect the financial resources and institutional culture. Laboratory instructional implications include new safety procedures to prevent distractions from the mobile technology. Student implications will affect how student participate in class and study outside of class with their mobile devices. The instructor implications could affect the way some instructors lecture and engage students in class. The third part of this chapter covers the recommendations for future research for mobile technology-based activities. These include research in areas of instruction and mobile device issues. The fourth part of this chapter covers the conclusions.

5.2 Research Purpose and Questions

This study was a comparison of learning performance between the students who use and the students who do not use mobile technology-based activities in a biological science course. Research questions that the study sought to answer include the following:

- Did the mobile technology increase students’ scores on quizzes and summative exams in lectures? If so, how and why?
- Did the mobile technology increase students’ scores on quizzes and summative exams in labs? If so, how and why?
- What benefits and challenges did students encounter in their learning during the mobile technology-based activities?
5.3 Discussion of Findings

The research findings were viewed through the activity theory. The tool (mobile technology) helped the subject (student) complete the object (mobile technology-based activities) which resulted in positive outcome (learning biology). As a result of using mobile technology-based activities the students in the mobile group had higher exam scores.

5.3.1 Pretest and Posttest Results

The lecture pretest compared the prior biology knowledge of the students in the two groups. The pretest scores did not indicate any significant difference between the two groups. This indicated that the students in the two groups had the same level of prior biology knowledge. The biology department lecture posttest scores for the two groups were not statistically different. This was consistent with the lecture exam scores. The mobile group improved their scores by an average 5.06 per student, and the non-mobile group improved their scores by an average of 3.63 points per student.

5.3.2 Lecture Quiz and Exam Comparisons

The lecture quizzes were from the textbook test bank of questions. The handouts over the chapter materials and mobile technology-based activities were not effective at improving student quiz score performance. Lecture quiz averages for the two groups were poor. For example, all of the average quiz scores were less than seven out of ten except for one Quiz9. The students in both groups said they only studied in class for a few minutes just before the quizzes. Most of them would study outside of class before the three exams.

Neither the handouts nor the mobile technology-based activities had any immediate
impact on these students studying for the quizzes. According to Scanlon & Issroff (2005), model of Activity Theory for higher education, to apply more influence on student, I could change the rules, tools, community, or activity. As the instructor I have the most impact on the rules of the class. A rule change could affect the student use of their mobile technology. Shih et al. (2010) research findings showed that the students, in that study, were motivated to use mobile technology. I could change the rules to require a passing class average on the first or second quizzes after each exam before the class could use their mobile devices in lecture. This could motivate the students and affect their learning outcomes on the quizzes. This type of change to the methodology would be an area of possible future research.

During the semester, the three lecture exam scores in the mobile group averaged 6.6 points higher on their learning outcomes than the non-mobile group exam scores, but the difference between the exam scores were not statistically significant. Mobile technology-based activities did result in positive student performance in the mobile group, but I learned from the focus group discussion that some of the activities needed to be changed to support different student learning styles and activity preference. The mobile technology-based activities in lecture were similar to the handout activities that required reading and answering questions. The students in the focus group that used mobile technology-based activities wanted the lecture activities to be more like the lab with engaging videos and images for their mobile device. Changing the lecture mobile technology-based activities in future to be more like the activities in lab could have a significant impact on student performance. Norris et al. (2011) research showed that one of the significant factors for positive learning outcomes was engaging learning activities created specifically for mobile devices.
5.3.3 Lab Quiz and Exam Comparisons

The mobile group had exam scores that were statistically significantly higher than the non-mobile group. Eta-squared for the three lab exams indicated that the independent variable (instructional method) could explain about eighteen percent of the variance in the dependent variable (exam scores). These results were similar to the results in the pilot study conducted in another semester. The mobile technology-based activities for lab often required students to put in their earphones to listen and watch videos over the activities before starting the lab experiment with their small group. The non-mobile group of students looked over the lab manual and completed the handouts with their small group before starting the experiment. Although, some of the time only a few members in each small group would be paying attention or doing the actual experiment. The mobile group also had a few students that did not actually do the experiments, but they all had earphones for listening and watching on their mobile devices to the activities before the experiment. Additionally, the biology lab experiments and results were conveniently photographed by the students in the mobile group to study later. The non-mobile group was told to draw or write down the experiments and results to study. Drawing and writing down a description of the experiment and results takes more time and effort at the end of lab, and most of the students did not take the time to draw or describe the results before turning in their work and leaving.

I examined these student’s actions in the non-mobile group through the rules of activity theory. According to Jonassen and Land (2000), rules inherently guided the actions or activities acceptable to the community (class). I determined that the rules of the lab allowed the students to turn in their work and leave without adequately recording the necessary information. I could change the rules, but I would have to provide some level of motivation before it would affect
their behavior. Allowing students to use their tool (mobile device) would provide them with the necessary motivation and a convenient resource, such as a camera, to complete the task before leaving the lab (Hwang & Chang, 2011; McConatha et al., 2008).

5.3.4 Combined Lecture and Lab Exam Results

To determine the overall effect of student exam scores, I compared the combined exam score averages and instructional method. The results of the comparison of the combined lab and lecture exam scores indicated a statistically significant difference between the mobile group and non-mobile group. The mobile group had a combine exam score average that was over eight points higher than the non-mobile group. Next, data assessment looked at other possible independent variables that could statistically significantly affect the dependent variable. Other possible independent variables such as age, gender, racial-ethnic, marital, and current education level were compared in this study. Data analysis indicated that none of the variables was statistically significant in this study.

5.3.5 Survey Results

The survey questions asked the two groups their opinion on the four parts: performance expectancy, effort expectancy, behavior intention, and self-management of learning (SL). Analysis of the student responses indicated that the students in both groups had similar responses for most of the survey except for SL questions. The first question that the groups differed on was SL3: I am able to manage my study time effectively and easily complete assignments on time. The mobile group ranked the question in the somewhat agree to agree part of the Likert scale, but the non-mobile group ranked this question between neutral and somewhat agree. The second
question that the groups differed statistically was SL4: In my studies, I set goals and have a high
degree of initiative. This indicated that the students in the non-mobile group ranked the question
somewhat agree, and the students in the mobile group ranked agree. The other two questions
(SL1 and SL2) were not statistically significant.

The student responses to these questions correlated with exam scores. Furthermore, the
regression analysis indicated that SL questions were predictive of lecture exams and combined
exams. A regression analysis was conducted to evaluate whether survey questions on SL were
predictive of combined groups lecture exam average scores for students in this study. Linear
regression analysis yielded a statistically significant effect indicating that SL explained 22% of
the variance in the combined groups lectures exam average scores. A regression analysis was
conducted to evaluate whether self-management of learning (SL) was predictive of combined
exam average scores. The regression analysis yielded a statistically significant effect indicating
that SL explained 19% of the variance in the combined exam average scores.

Analysis for lab exams indicated that student responses for SL were not as predictive as
the instructional method. A regression analysis evaluated if SL was predictive of lab exam
average scores. The regression analysis yielded a statistically significant effect indicating that SL
explained 12% of the variance in the lab exam average scores. This result indicated that the
student survey responses to the SL questions were predictive of a small but significant amount of
the lab exam scores. A linear regression analysis compared the lab exam average scores and the
two possible independent variables, instructional method and SL. The regression analysis yielded
a statistically significant effect. After separating SL and instructional method the results
indicated the score for the instructional method was statistically significant as compared to SL.
The analysis indicated that instructional method, \( t=2.247, p = 0.30 \), was statistically significantly
better predictor of lab test scores than SL, $t=1.511$, $p = 1.39$. Other possible independent variables such as age, gender, racial-ethnic, marital, and current education level were compared in this study. The other possible variables were not found to have a statistically significant effect in this study.

The survey responses were also used to compare the members of the two focus groups opinions about mobile learning. Unlike the survey results that were different for SL that included all the students in both groups, the focus groups were the same in all four of the survey areas. The smaller focus group survey data was not statistically different from each other in all fours parts of the survey.

5.3.6 Focus Group Interview Results

Focus group code analysis resulted in three themes. The categories were named category of disadvantages, category of depends, and category of benefits. The category of disadvantages was supported by four themes. The largest theme called technology deficiency theme was defined as the issues from learning with mobile technology. Some of these issues discussed were real issues that affected the students in the mobile group, and the others issues discussed were theoretical. For example, some students did have problems early in the semester with the small screen size of their device. A possible issue discussed in the non-mobile group was battery failure. Battery limitations in mobile devices were discussed by Fisher and Baird (2006) as an issue to consider with mobile learning. Battery failure was not a problem because of the extra mobile devices that were available for the students. The next theme was called distraction theme. Students discussed how they could be distracted by Facebook and other social media that is accessible to them on their mobile device. Two other themes called book preference theme and
effort theme were discussed in the category of disadvantages. For the students using the mobile technology-based activities, the book preference theme was related to being distracted by the easy access to social media and a personal preference for books instead of technology. The effort theme was from the non-mobile group. Several of these students believed that mobile technology-based activities would make them lazy because they could use Google the find the answers.

The category of disadvantages will take time and research to find the solutions for all of the issues students discussed. There are technological solutions for some of these issues, but these will cost institutions more money. For example, the institutions can provide devices for students to use in a particular class, or they can issue mobile devices to every full-time student just like the identification cards and parking permits. The cost for this type of solution will be passed on to the students in tuition and fees. As discussed by Franklin (2011), mobile device with a large screen size would address the issue of not being able to see the activities, but the cost of these devices could limit access for every student. The issue of battery failure could be address with charging stations and supplemental mobile devices. The class distraction issue could be reduced by requiring the student using a mobile device to log into a wireless classroom control system. This system will constantly have an image of each students screen visible to the instructor, and the social media websites could be restricted (Aerohive, 2013). Unfortunately, none of these technological solutions addresses every issue with mobile technology-based activities. Another way to approach these disadvantages would be with classroom management and policies. As a result of this study, I learned the difficultly that can occur trying to restrict students from using mobile technology in class. The students in the non-mobile group wanted to check their text messages and Facebook, but I told them to wait until class was over to check.
The themes that supported the category of disadvantages should be part of future research in mobile learning.

The category of depends was supported by two themes. The first theme was called subject theme because the students indicated that their use of mobile technology-based activities would be affected by the subject. For example, several of the students discussed math and healthcare as subjects that could benefit from mobile technology-based activities for learning. Math was a subject that had online activities and several of the students in the focus group had used these online math activities. The ability to engage using mobile technology in math was described by Hawkes and Hategekimana (2009) as a factor in higher student learning outcomes. The students that had a positive experience with this math program were engaged in the math activities. The other students in the focus group that had a negative experience with the software were not engaged. After listening to the focus group discuss their experiences with the online math activities, I determined that the student’s negative experiences were from the restrictions that instructors put on the software. These restrictions inhibited the students from engaging with the activities. Healthcare was discussed by students in both focus groups as a subject that mobile technology should be used. These students that discussed healthcare were either undergoing regular medical treatment or they had family that used mobile technology working in healthcare. The use of mobile technology in healthcare is currently being researched, and the applications of mobile technology in healthcare will be an area of continued research for many years (Brady et al., 2009). The next theme was called personal preference theme. Some of the students discussed that the use of mobile technology for learning could be a personal preference. Providing students with several options so they could choose how they were presented the course material to learn would be difficult and time consuming for one instructor to develop. However, the availability of
large amounts of online materials and activities could reduce the amount of work an instructor (Franklin, 2011). Another challenge of trying to develop materials for students to learn based on their preference would be assigning a grade for different types of work. I think changing instruction to match personal learning style or preference could be done with more research.

The category of Benefits was supported by three themes. The learning theme was defined as students learning with mobile technology. Students always have their smartphones or other mobile devices with them, but they do not always carry their books with them to study at work. One of the benefits for the students using mobile technology-based activities was described as the ability to learn a little at a time while on a lunch break or waiting in line for something. All of this extra time on task spent learning course material should increase student performance (Norris et al., 2011). The students in the mobile group described the use of mobile technology in class as a way to keep them awake and engaged in learning. Student could take advantage of the convenient access to resources that mobile technology provided for improved student learning outcomes (McConatha et al., 2008). The difficulty and type of the activity needs to be researched to determine which activities would produce the best results. New technologies that have been developed could be used to remind students directly on their phones to study. Additionally, I think this technology should be researched to determine the fine line between helpful reminders and harassment.

The adapting to change theme came from the students in the focus group that wanted the institution and instructors to keep up with the changing times. As I used activity theory to analyze this theme, I saw that the community (higher education institution) will be difficult to change. In ten years of teaching, I have seen the community adapting to change because it was necessary for survival.
5.3.7 Pedagogy and Problem-based Learning

The pedagogy for this study allowed students to learn with their mobile devices. The students in the mobile group described how they liked using their mobile devices to help them learn biology while on the go. These students described their preference for the hands-on mobile technology-based activities in lecture and lab. Some of the students preferred used only certain parts of the activities. These parts of the activities worked best with their learning style, or the activities kept them engaged in class. The use of mobile technology by the students in the mobile group allowed these students to learn biology using several different activities. These activities included technology and problem-based learning. Problem-based learning comes from the medical schools in the 1950s (Hung, Jonaseen, & Liu, 2008). Students in medical schools needed to learn real life problem-based clinical skills to diagnose patients. According to Hung, Jonaseen, and Liu (2008), problem-based learning was used in biology and other areas of higher education in the 1990s. Some of the students in the mobile group had wide gaps in knowledge about using technology, and other students knew a lot about using mobile technology for learning. This difference in the level of mobile technology knowledge was a problem on the first day of class. To address this problem, I put the students into teams. Every team had someone that had experience using mobile devices for learning. The students worked together to help each other get familiar with their mobile technology. To get the teams to work together, I gave the teams several mobile technology problems.

The mobile technology problems that I assigned to the teams required the following: communication with each other, use of technology, and sharing information with the class. The first problem required the students to exchange basic contact information, and the teams were to send an email with the contact information to each other. They were not told how to complete
this assignment. This problem without clear step-by-step instructions made some of the students uncomfortable, but I told them to work with their team. Each team had their own solutions for this problem. Some of the teams had each person send an individual email to each team member, and other teams had only one person send an email to everyone. Then one of the team members described to the class how they solved the problem. This activity was designed to engage the students that had more than basic knowledge of how to use their mobile device for learning. All of the activities were designed to teach to the students in the technology middle. I did not want the tech savvy students to get to bored and distracted because the activities were too simple, and I did not want the students that were novices to mobile technology to become frustrated. The next problem I had the teams work on was the QR Code reader.

The QR Code reader was an app that all the students needed on their mobile device to access the activities. This problem required the students to access their mobile device’s app store. Then the teams helped each other to find the QR Code reader and download the app. This problem kept the tech savvy students busy helping their team members that were having difficulty accessing the QR Code reader. This activity helped to build team unity. Additionally, the activity kept the tech savvy students from being distracted, and the students that were not familiar with mobile technology did not get as frustrated because they had some help. The students did have some problems with their mobile devices and the QR Code reader.

These app problems were related to the compatibility of the instructor suggested QR Code reader and the student’s mobile device. The compatibility issue with apps on mobile devices was a possible concern for mobile learning. The solution was to test several different apps that could accomplish the same task (Cone, 2013; Parsons, 2010). The technology required for the activities was very common, and almost all mobile devices now have several different QR
Code reader apps available free. This type of activity provided the students in the mobile group an opportunity to learn about each other and to start learning how to work together. This activity was for a student that had more than basic knowledge of how to use their mobile device. All of the activities were designed to teach to the student in the technology middle. The more tech savvy students helped the less tech savvy students at the beginning of the semester with the activities. According to Warren and Wakefield (2011), this type of learning was based on social constructivist pedagogy. The students worked together to socially construct new knowledge about their mobile devices and the biology activities.

5.3.8 Summary of Results

Summary of data assessments evaluated the effect that the independent variable (instructional method) could explain about the variance in the dependent variable (exam scores). The exam scores between the two groups were affected by the use of mobile technology-based activities. There was no statistically significant difference between the two groups in lecture quizzes or exams. The mobile group did have a statistically significant difference in lab exams exam scores as compared to the non-mobile group. Eta-squared for the three lab exams indicated that the independent variable (instructional method) could explain about eighteen percent of the variance in the dependent variable (exam scores). There were no statistical differences between the lab quizzes and the groups. The combined lecture exam and lab exam comparison between instructional method and the all of the combined exam average scores indicated a statistically significant difference. The mobile group combined exam average scores were over eight points higher than the non-mobile group.
The survey asked the two groups their opinion on mobile learning. The questions were about using mobile technology and their performance expectancy, effort expectancy, behavior intention and self-management of learning. Prior research with business students by Lowenthal (2013) indicated that performance expectancy, effort expectancy, and self-management of learning predicted behavior intention. That was not the case with the biology students in this study. Their survey responses for self-management of learning did not correlate with effort expectancy or behavioral intention to use mobile technology for learning. The survey responses for self-management of learning did correlate to exam scores. The survey responses from SL were compared to lecture exams, lab exams, and combined exam scores. The results indicated that the student responses for SL were predictive of lecture exam and combined exams, but the regression analysis for lab exams indicated that student responses for SL were not as predictive as instructional method. Additionally, the data assessment looked at other possible independent variables that statistically significantly affected the dependent variable. Regression analysis indicated that none of the other possible independent variables compared were statistically significant in this study.

Analysis of the focus groups resulted in three categories that were named Disadvantages, Depends, and Benefits. The category of Disadvantages was supported by four themes. The largest theme was called technology deficiency. Technology deficiency theme defined all the different technology issues from learning with mobile technology. Some of these issues discussed did affect the students in class and the others were possible issues. For example, the mobile group had specific issues with technical problems that prevented them from accessing the activity. The lack of adequate access inhibited student learning. The non-mobile group had examples of technology deficiencies that were about the device. These issues included: cost,
battery, loss or no access to a device, and not understanding how to use the device. The next largest theme was distraction. The distraction theme referred to mobile technology distracting students from learning. Many of the students in the mobile group described how easy access to social media (Facebook) on their mobile technology was distracting. Other distractions that this group described included: videos, messaging friends, online shopping, and porn. The non-mobile group also described how they would be distracted by social media. One of the students described the easy one click access to Facebook as being tempting. The students in the mobile group had a book preference because of concerns over technical problems and distraction from social media. In the non-mobile group, the student’s comments about preferring a textbook were a personal preference. One student just preferred a book instead of technology. The effort theme was used to define all the student answers that described how mobile technology would negatively change their effort to learn. All of the students that indicated that mobile technology would negatively influence their effort were in the non-mobile group. They said using mobile technology might make them lazy because they could easily look anything up.

The category of Depends was supported by two themes. The subject theme was used because the students referenced particular subjects when they answered if using mobile technology would change their effort in other classes. Students in the mobile group indicated that using mobile technology would change their effort in math, history, and English. All three subjects were discussed by these students with both positive and negative results after using technology in these subjects to support their learning. The non-mobile group discussed using mobile technology for English class. One of the students described using her device to help her read, but another student said she would need a reason to use mobile technology in English. The personal preference theme was used because the students talked about personal beliefs and
feelings toward using the technology when they answered the questions about mobile technology changing their effort in class. A student in the mobile group described using how mobile technology-based activities could be used in his other classes for engagement. He described how the activities could be used to quiz the students over a short lecture, and he said the mobile activities would help keep him from falling asleep in class. In a negative example, the student described a class that had the entire book on the course management system. She did not like reading from her smartphone. A textbook would have been easier to read than her smartphone.

The category of Benefits was supported by three themes. Learning was the largest theme. It was defined as students learning with mobile technology. The students in the mobile group described how the mobile technology-based activities benefited the students with different learning styles. These students wanted to see more videos and images about the course content. Mobile technology was described as convenient and efficient for learning by both groups. A couple of the students liked the convenience of accessing the activities from their devices on their lunch breaks at work. They always have their smartphones with them, but they do not carry around their books. The short activities were liked because of efficiency. One of the student said the activities did not have unnecessary information. The non-mobile group described using mobile technology to look up information, meet online, and as a source for a broader range of ideas. After the learning theme, the theme with the most occurrences was called adapting to change. This theme was only from the students in the mobile group. These students discussed the need to adapt teaching and learning to keep up the changing times and technology. Students in the mobile group wanted their teachers and the institution to change because the technology was here to stay. Another reason to adapt to changing technology was the need to know how to use this technology in the workforce. The last theme was called mobile learning preference. These
students in the mobile group like the hands-on experience using their device, and the change of pace in the lab and lecture helped to keep them engaged and awake. In the non-mobile group, only one student described her mobile learning preference. She described how she enjoyed using her mobile devices, and she thought other people would enjoy using them for learning.

The students in the mobile group used the mobile technology-based activities to improve their lab exams scores over the non-mobile group using handouts. The survey item analysis indicated that both groups were statistically the same in their opinion of performance and effort expectancy, but the mobile group ranked their ability to manage their own learning higher than the non-mobile group. Self-management of learning was a predictor of lecture exam scores, but it was not a significant predictor of lab exams scores. The themes from the data provided by the two focus groups answered the research question about the benefits and challenges that students encounter with mobile technology-based activities. The focus group with students using mobile technology had specific and detailed answers. non-mobile group provided a more open prospective of the possible problems from using mobile technology for learning. The mobile group spoke more favorably towards mobile technology-based activities than the Non mobile group, especially in learning, adapting to change, and mobile learning preferences.

5.4 Implications

The results study has direct implications on instruction in lecture and lab, students, and the institution. The mobile technology-based activities were successful at significantly improving student exam performance for the mobile group. The mobile group exam scores were eight points higher than the non-mobile group. As a result of the increased student performance the other instructors in the biology department have asked for these activities for their students, and
in the next semester, all of the biology courses will be supported by the textbook publisher’s course management system that includes a mobile app.

I believe there were several reasons that instructors resist changing to mobile technology-based activities. For instance, the mobile technology-based activities for my biology classes and labs required days to develop the activities. I believe the lack of time necessary to develop these activities was one of the main reasons other instructors were resistant to adopting mobile technology-based activities. However, there were instructors where I work that wanted to learn how to use this technology in their teaching. They just do not have the time to develop the activities.

The change necessary before many instructors will begin to use mobile technology-based activities would be from the textbook publishers. Textbook publishers need to change the supplemental instructional technology that comes with the textbooks from personal computer based instructional materials to instructional materials for mobile devices. The implication for this type of change would help start the movement toward large scale adoption of mobile technology-based activities. As the textbook publishers provided supplemental instructional technology for mobile devices, instructors would be able to use mobile technology-based activities without spending hours developing and learning new technology.

As was demonstrated by this study, the implications for changing to mobile technology-based activities for most students will be positive. Students could use their mobile technology to learn in class, and then bring the activities with them to review and study before the exams. This type of change will develop over time. However, there are some students that do not want to hear from or engage with any of their classmates at all. These students only want to know what they need to learn to answer the questions on the test, and then they want to leave. Mobile
technology-based activities may not be the best form of instruction for this type of student. However, all of the students in the mobile group wanted mobile technology-based activities in their other classes.

The implications of mobile technology-based activities that this study demonstrated could act as example for other instructors. To get other instructors to adopt this type of instructional method in their classes would require training to change from a traditional PowerPoint lecture to a class with engaging instructional technology. According to the students in the focus group, this type of change was what they wanted in their classes. They wanted their classes to be engaging. They wanted to do more than sit and listen to a monotone lecture that puts them to sleep.

When mobile technology-based activities are implemented in the classroom and the laboratory, it will require both the students and the instructor to adjust to several potential issues discussed by the focus group. Technology deficiency theme will always be a problem at some level in the classroom. Technology deficiencies could cause a great deal of frustration as was stated by Allie in the focus group interview. I have learned that almost all of the technology issues can be resolved by being flexible and adjusting to the situation, but this will be a challenge to instructors that already feel they have enough to worry about without trying to get a mobile device to work during class.

The effort theme was the result of comments by student in the non-mobile group. These students believed that mobile technology could provide them with all the answers to the questions. This may be true if all the questions in life were multiple-choice, but the students in the mobile group found out that the technology helps you find other possible answers to the questions. This caused some of the students in the mobile group concern because the answers did not match the book word for word. As an instructor, the implication of these other answers to the
questions provide a way to bring engaging discussion into the classroom.

The distraction theme has become a difficult issue for my students. This issue has become a larger problem in every class and laboratory that I have taught in the last five years. The distractions used to be just ringing phones and text messages, but social media has brought a completely new level of distraction to class. For example, a student at the college was killed in a car crash on her way to class, and everyone in the laboratory was distracted because they were getting updates from Facebook. The information spread so fast with Facebook the Office of Student Service was forced to respond by email in just a few minutes, whereas in the past this type of information would require a press release.

Using mobile technology in the laboratory could create several safety issues. As a result, basic safety guidelines for using a mobile device in lab need to be developed. This safety information will need to become part of the routine lab safety training at the beginning of the semester. The lab safety training will need to address the hazards of distraction with a mobile device and the risks to the technology.

The institutions or the lab instructors will have to decide which labs they are going to allow students to use mobile technology. For example some wet-labs may not be practical because of the large amounts of water that could destroy the technology. Additionally, students will have to consider if they are willing to risk their mobile device being possibly damaged in the lab.

The institutional implications for mobile technology-based activities could include financial and cultural. If students bring their own mobile device to class the institutions could save money because the institution would only need to buy a few supplemental mobile devices for students that do not have one or forgot their device. These devices do not need to be the most
expensive mobile technology for students to participate. The cost of a few supplemental mobile devices would be less expensive than the institution buying multiple computer labs. A reduction in the number of computer labs purchased would save money by reducing the electrical power used for air conditioning to cool the computer labs. Additional, IT cost saving could come from the installation and maintenance of these computer labs. However there may be new cost because the institution would need to provide basic support for instructors and students that were learning how to use their mobile device. The cost to train instructors and staff would eventually be less because most of the mobile devices today are intuitive to use.

At the institution where I have taught for over ten years, the use of mobile technology-based activities will be disruptive to most of the culture of teaching. For example, mobile technology in the classroom was banned as a campus wide policy until recently. Many of the instructors still do not permit students to use their mobile devices for anything other than emergency communication. It will take a lot of time before the culture at the institution where I teach to adopt mobile technology-based activities. At one time, I thought that an effective strategy could introduce mobile technology for instruction, but my institution’s President Dr. Bill Holda said, “I need to remember that culture eats strategy for breakfast.” With that advice in mind, I think that slow adoption of this technology will continue as the culture adapts to more instructors using mobile technology in their classrooms. Additional pressure could come from the students as more of them have mobile technology. The students in the focus group wanted the instructors and the institution to adapt to changing times, and many of them expect to be able to use their technology to help them learn. The implications at other institutions will be impacted by the willingness of the culture at each institution to accept the possible changes from mobile technology.
5.5 Recommendations

My first recommendation for future research with mobile technology-based activities includes expanding this study to more students and different subjects. For example, this study could be increased to include other instructors and different biology courses to determine the effect on a much larger number of students. The students in the focus group interviews discussed several subjects that they believed mobile technology-based activities could be used. Future research could include these other subjects for a comparison. Another issue that needed research was the risk to student safety using mobile devices in the laboratory. This could be researched with a large survey of several different types of laboratories.

The students that were using the mobile technology-based activities wanted the lecture activities to be changed to include more video and images, and future research could compare effectiveness of these different activities. The students in the mobile group discussed during the focus group interviews that mobile technology could be used to match different learning styles. For example, the activities could be designed for different learning styles and the students choose the activity that best fits their own learning style. Then compare student engagement, exam performance, and type of activities completed by the students.

5.6 Conclusions

Using mobile technology-based activities was an effective method of instruction for students in the mobile group. The use of mobile technology for direct instruction will become more common in the coming years in biology. This process of using these types of activities will help students learn while they have a few minutes in their busy day. For example, students will always have their mobile device with them, and this constant access to technology should be
used to provide them opportunities to learn. Some of the students in the mobile group were already learning this way during this study. They were using their mobile devices to study while they were on lunch breaks at work and waiting in between class. Students were not bringing their books to work to study, but they will rarely leave home without their mobile device. All of the students in this study always had their mobile devices with them in class or lab. Instructors should use mobile technology-based activities to provide students with motivating and engaging learning activities that improve learning outcomes in biology. These mobile technology-based activities should take advantage of student’s access to this technology to support their learning in the laboratory.

The benefits and challenges of mobile technology for learning included several areas that will need more research. The challenges from the distractions like social media and the technology deficiencies from problems with the technology must be managed to get the most benefit out of the mobile technology-based activities. A benefit to the students in this study was the engaging hands-on activities that helped keep them interested and awake. The most important benefit to the students in this study was the convenience of learning on their mobile device that was with them at all times.
APPENDIX A

QR CODES AND WEB LINKS FOR LECTURE ACTIVITIES
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APPENDIX B

MOBILE GROUPS SAMPLE CLASSROOM ACTIVITIES
Daily Classroom Activities

1. Class discussion about the chapter.

2. The students were given QR Code or web link to the activity.

Skin & Sun

Part 1
- [http://tinyurl.com/aefsnyg](http://tinyurl.com/aefsnyg)

Part 2
- [http://youtu.be/Tp9ch77C56Q](http://youtu.be/Tp9ch77C56Q)

3. They access the activity and work to answer the questions.

- What does the skin produce from sunlight?
- What is melanin and where is it found?
- What is a tan?
- What is SPF on the sunscreen?
- How often should you reapply sunscreen?
- What hours of the day should people with little melanin limit their exposure to the sun?
- Why should everyone where UV protected sunglasses?
Classroom Activities to Review for Exam

One of the classroom activities was a game called head-to-head. This game required all the teams to go against each other at the board answering questions. This activity was part of the daily grade. It was worth up to 25 points for first place and down to 10 points for the last place team. All students were required to play the game. By allowing the team to answer on the third question, that helped to keep the class engaged. The following are the rules for this activity:

- The first rule, students could only take note or record the questions and answers.
- The second rule, students could not use their book or their device to look up the answers in the game.
- Third rule, during this activity a member from each team had to rotate at the front of the class every three questions.
- The fourth rule, questions one and two asked to each student must have their answers written on the board.
- Fifth rule, on the third question the team was allowed to give their teammate the answer.

Another classroom activity was called around-the-room. This game was played to review for the exam. The points were the same as the head-to-head game. The following were the rules to the game:

- To play around-the-room, the teams were asked questions by the instructor.
- If the team missed the question or could not answer the question in 10 seconds, then the questions went to the next team.
• This process continued until all of the teams had a chance to answer the question. Then the instructor would discuss the correct answer with the teams.

• The instructor would start the game again with the next team
APPENDIX C

NON-MOBILE GROUP SAMPLE CLASSROOM ACTIVITIES
Daily Classroom Activities

1. Class discussion about the chapter.

2. The students were given QR Code or web link to the activity

3. The use their textbook to complete the handout.

Classroom Activities to Review for Exam

   One of the classroom activities was a game called head-to-head. This game required all the teams to go against each other at the board answering questions. This activity was part of the daily grade. It was worth up to 25 points for first place and down to 10 points for the last place team. All students were required to play the game. By allowing the team to answer on the third question, that helped to keep the class engaged. The following are the rules for this activity:

   • The first rule, students could only use their digital devices to record the questions and answers.

   • The second rule, students could not use their book or digital devices to look up the answers in the game.

   • Third rule, during this activity a member from each team had to rotate at the front of the class every three questions.

   • The fourth rule, questions one and two asked to each student must have their answers written on the board.

   • Fifth rule, on the third question the team was allowed to give their teammate the answer.

   Another classroom activity was called around-the-room. This game was played after the classes had covered the final two chapters of the four chapters on the second exam. The points were the same as the head-to-head game. The following were the rules to the game:
• To play around-the-room, the teams were asked questions by the instructor.
• If the team missed the question or could not answer the question in 10 seconds, then the questions went to the next team.
• This process continued until all of the teams had a chance to answer the question. Then the instructor would discuss the correct answer with the teams.
• The instructor would start the game again with the next team
APPENDIX D

SAMPLES LECTURE QUIZ AND EXAM
Sample Quiz

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The most important minerals stored in bones are:
   A) sodium and potassium
   B) calcium and phosphorus
   C) calcium and iron
   D) sodium and phosphorus
   E) calcium and potassium

2) The axial skeleton contains:
   1. skull  2. arms and legs  3. ribs and sternum  4. Vertebrae  5. pelvic girdles
   A) 1, 3, 4
   B) 1, 3, 4, 5
   C) 1, 2, 3, 5
   D) 2, 5  E) 2, 3, 4, 5

3) A round or oval opening through a bone is a:  3) _______
   A) facet
   B) foramen
   C) fissure
   D) fossa
   E) trochanter

4) What tiny canal connects central canals to lacunae in compact bone:  4) _______
   A) canaliculus
   B) perforating canal
   C) osteon
   D) Haversian canal
   E) lamella

5) Which of the following bones is NOT considered part of the appendicular skeleton?
   A) sternum
   B) radius
   C) scapula
   D) metatarsals
   E) femur

6) The presence of an epiphyseal plate indicates that:
   A) bone length is no longer increasing
   B) bone length is increasing
   C) bone is dead
   D) bone diameter is decreasing
   E) bone diameter is increasing
7) The femur, tibia, humerus, and radius are all classified as:
A) irregular bones
B) long bones
C) sesamoid bones
D) flat bones
E) compact bones

8) What kind of tissue is the forerunner of long bones in the embryo:
A) elastic connective tissue
B) loose fibrous connective tissue
C) fibrocartilage
D) hyaline cartilage
E) dense fibrous connective tissue

9) What type of tissue covers the epiphysis of bones and reduces friction in the joints:
A) cartilage
B) yellow marrow
C) endosteum
D) periosteum
E) spongy bone

10) The hyoid bone is unique because:
A) covered with mucosa
B) it has no specific function
C) it largely consists of cartilage
D) it has an unusual shape
E) it is the only bone of the body that does not directly articulate with any other bone
Sample Exam
Name___________________________________

1) The pigmented portion of the eye that has a rounded opening through which light passes is
the:
A) lens
B) iris
C) cornea
D) retina
E) sclera

2) The hyoid bone is unique because:
A) it has no specific function
B) it has an unusual shape
C) it is the only bone of the body that does not directly articulate with any other bone
D) it largely consists of cartilage
E) it is covered with mucosa

3) Bone formation can be referred to as:
A) gout
B) ossification
C) rickets
D) osteoporosis
E) osteoarthritis

4) Which two bones constitute the forearm:
A) fibula and tibia
B) ulna and radius
C) humerus and scapula
D) femur and fibula
E) radius and humerus

5) The wrist bones are actually:
A) metatarsals
B) tarsals
C) phalanges
D) carpals
E) metacarpals

6) Which is the correct order of ribs, from superior to inferior:
A) floating ribs, false ribs, true ribs
B) true ribs, floating ribs, false ribs
C) true ribs, false ribs, floating ribs
D) floating ribs, true ribs, false ribs
E) false ribs, floating ribs, true ribs
7) The axial skeleton contains:
   1. skull
   2. arms and legs
   3. ribs and sternum
   4. vertebrae
   5. pelvic girdles

A) 1, 3, 4, 5
B) 1, 2, 3, 5
C) 1, 3, 4
D) 2, 5 E) 2, 3, 4, 5

8) Which of these bones is associated with the hand:
   A) metatarsals
   B) metacarpals
   C) tarsals
   D) calcaneus
   E) talus

9) A compound fracture can be described as when:
   A) the bone is crushed
   B) adjacent bones fracture simultaneously
   C) the broken bone is exposed to the outside
   D) the bone is broken into many fragments
   E) the broken bone ends are forced into each other

10) Which of the following groups of bones in the human body, categorized according to shape,
    is correct:
    A) cranium - sesamoid bones
    B) coxal bones - short bones
    C) arm and leg bones - short bones
    D) skull bones - flat bones
    E) wrist and ankle bones - long bones

11) What kind of tissue is the forerunner of long bones in the embryo:
    A) fibrocartilage
    B) elastic connective tissue
    C) loose fibrous connective tissue
    D) hyaline cartilage
    E) dense fibrous connective tissue
12) In adults, the function of the yellow marrow is to:
A) decrease friction at joint surfaces
B) form blood cells
C) store adipose tissue
D) cause lengthwise growth in long bones
E) store calcium and phosphorus

13) Which of the following bones is NOT considered part of the appendicular skeleton:
A) femur
B) sternum
C) scapula
D) radius
E) metatarsals

14) A round or oval opening through a bone is a:
A) fossa
B) trochanter
C) foramen
D) fissure
E) facet

15) The most important minerals stored in bones are:
A) sodium and potassium
B) calcium and iron
C) calcium and phosphorus
D) calcium and potassium
E) sodium and phosphorus

16) The femur, tibia, humerus, and radius are all classified as:
A) long bones
B) compact bones
C) irregular bones
D) flat bones
E) sesamoid bones

17) Anaerobic glycolysis occurs without:
A) carbon dioxide
B) ATP
C) oxygen
D) lactic acid
E) glucose
18) Which of the following muscles are antagonists:
A) gastrocnemius and soleus
B) biceps brachii and triceps brachii
C) masseter and temporalis
D) biceps femoris and biceps brachii
E) vastus medialis and vastus lateralis

19) Which congenital muscle disease results from the degeneration and atrophy of muscles:
A) scoliosis
B) muscular dystrophy
C) multiple sclerosis
D) myasthenia gravis
E) spina bifida

20) Which of these muscles is NOT located in the head:
A) sartorius
B) buccinators
C) frontalis
D) zygomaticus
E) orbicularis oculi

21) Voluntary muscle tissue is:
A) skeletal muscle
B) smooth muscle
C) dense irregular
D) cardiac muscle
E) dense regular

22) The condition of skeletal muscle fatigue can be best explained by:
A) insufficient intracellular quantities of ATP due to excessive consumption
B) the inability to generate sufficient quantities of ATP due to feedback regulation of synthesis
C) the all-or-none law
D) inadequate numbers of mitochondria
E) a total lack of ATP

23) Which one of the following is composed of myosin protein:
A) light bands
B) thick filaments
C) all myofilaments
D) Z discs
E) thin filaments
24) A single, brief, jerky muscle contraction is termed:
A) anaerobic
B) tetanus
C) isotonic
D) isometric
E) twitch

25) The gap between the axon terminal of a motor neuron and the sarcolemma of a skeletal muscle cell is called the:
A) cross bridge
B) sarcomere
C) neuromuscular junction
D) synaptic cleft
E) motor unit

26) Acetylcholine is:
A) a source of energy for muscle contraction
B) an ion pump on the postsynaptic membrane
C) a component of thick myofilaments
D) an oxygen-binding protein
E) a neurotransmitter that stimulates skeletal muscle

27) The gap between two communicating neurons is termed:
A) Schwann cell
B) synaptic cleft
C) node of Ranvier
D) cell body
E) effector

28) A sarcomere is:
A) the area between two intercalated discs
B) the wavy lines on the cell, as seen in a microscope
C) a compartment in a myofilament
D) the nonfunctional unit of skeletal muscle
E) the contractile unit between two Z discs

29) Which of the following is NOT a function of the muscular system:
A) production of movement
B) generation of heat
C) maintenance of posture
D) hematopoiesis (blood cells)
E) stabilization of joints
30) Smooth muscle cells are:
A) multinucleate
B) branched
C) involuntary
D) cylindrical
E) striated

31) Preparing the body for the "fight-or-flight" response during threatening situations is the role of the:
A) cerebrum
B) sympathetic nervous system
C) parasympathetic nervous system
D) somatic nervous system
E) afferent nervous system

32) The function of the olfactory nerve concerns:
A) chewing
B) eye movement
C) vision
D) smell
E) hearing

33) The blood-brain barrier is effective against the passage of:
A) nutrients such as glucose
B) anesthetics
C) metabolic waste such as urea
D) water
E) alcohol

34) Which of the following brain dysfunctions is also known as a stroke:
A) cerebrovascular accident (CVA)
B) Alzheimer's disease
C) cerebral edema
D) Parkinson's disease
E) aphasia

35) Loss of muscle coordination results from damage to the:
A) cerebellum
B) midbrain
C) hypothalamus
D) cerebrum
E) thalamus
36) Muscles and glands are:
A) part of the peripheral nervous system
B) receptors
C) part of the central nervous system
D) effectors
E) myelinated

37) The vital centers for the control of visceral activities such as heart rate, breathing, blood pressure, swallowing, and vomiting are located in the:
A) cerebrum
B) medulla oblongata
C) hypothalamus
D) iris
E) midbrain

38) The substance that is released at axonal endings to propagate a nervous impulse is called:
A) a neurotransmitter
B) an ion
C) an action potential
D) nerve glue
E) the sodium-potassium pump

39) Which one of the following is NOT a primary taste sensation:
A) salty
B) pungent
C) bitter
D) sour
E) sweet

40) The Schwann cell forms a myelin sheath around the:
A) nodes of Ranvier
B) cell body
C) axon
D) dendrites
E) nucleus

41) The term central nervous system refers to the:
A) autonomic and peripheral nervous systems
B) brain and spinal cord
C) spinal cord and spinal nerves
D) brain, spinal cord, and cranial nerves
E) brain and cranial nerves
42) An ear infection following an illness such as a cold can pass from the throat through the auditory tube to the:
A) eardrum
B) semicircular canals
C) middle ear
D) outer ear
E) inner ear

43) Which area of the retina lacks rods and cones and therefore does not detect images:
A) choroid
B) ciliary body
C) optic nerve
D) optic disc
E) fovea centralis

44) Equilibrium receptors are located in the:
A) ossicles
B) inner ear
C) tympanic membrane
D) external ear
E) middle ear

45) Sound waves entering the external auditory canal hit the eardrum, also known as the:
A) auricle
B) oval window
C) ossicles
D) pinna
E) tympanic membrane

46) What structure of the eye focuses light on the retina:
A) choroid
B) optic chiasma
C) iris
D) lens
E) sclera

47) Tough, white connective tissue forms this portion of the fibrous layer of the eye:
A) retina
B) choroid
C) sclera
D) conjunctiva
E) cornea
48) Which layer of the eye contains rods and cones:
A) optic nerve
B) choroid
C) retina
D) iris
E) sclera

49) Which region of the retina contains only cones and is the sharpest area of visual acuity:
A) choroid
B) retina
C) sclera
D) cornea
E) fovea centralis

50) Inflammation of the conjunctiva involves which of the following:
A) circular band surrounding the pupil
B) extrinsic eye muscles
C) glands that produce tears
D) portion of the eye that contains the optic nerve
E) delicate membrane lining the eyelids and covering the front of the eyeball

51) The pupil is an opening within the:
A) iris
B) lens
C) retina
D) sclera
E) choroid

52. The condition called osteoporosis causes a ____________
   a. tooth decay
   b. decrease in bone mass
   c. increase in bone mass
   d. hematoma

53. Sinuses within some bones of the skull act to
   a. decrease the weight of the bone
   b. thicken the bone
   c. increase density
   d. lubricate the muscle

54. Which is not part of the appendicular skeleton?
   a. humerus
   b. rib
   c. phalanges
   d. calcaneus
55. The anatomical term for the "breast bone" is the:
   a. true rib
   b. hanging rib
   c. hyoid
   d. sternum

56. Which of the following is NOT a function of bone?
   a. supporting body
   b. internal frame work
   c. protect soft organs
   d. nerve signal

57. Individual Ribs that attach directly the sternum are called _________.
   a. true rib
   b. hanging rib
   c. hyoid
   d. sternum

58. ____________ attaches a muscle to a bone.
   a. ligament
   b. tendon
   c. myelin
   d. fissure

59. The intercostal are found on the ______:
   a. shoulder
   b. ribs
   c. femur
   d. calcaneus

60. Which of the following is a function of muscle tissue?
   a. supporting body
   b. movement
   c. protect soft organs
   d. nerve signal

61. Which of the following is not a characteristic of cardiac muscle?
   a. intercalated disc
   b. involuntary control
   c. uninucleate
   d. multinucleate
62. Axons normally carry information away from the _____.
   a. nerve cell body  
   b. dendrites  
   c. neurotransmitter  
   d. Schwann cell

63. ________ carry information toward the nerve cell body.
   a. nerve cell body  
   b. dendrites  
   c. neurotransmitter  
   d. Schwann cell

64. A neurotransmitter is released from the:
   a. synaptic cleft  
   b. synaptic vesicles  
   c. acetylcholine  
   d. axon terminal

65. The corpus callosum connects the:
   a. cerebellum  
   b. pons  
   c. medulla oblongata  
   d. cerebral hemisphere

66. Fovea centralis only cone cells and is found in the ______.
   a. ear  
   b. eye  
   c. medulla oblongata  
   d. cerebral hemisphere

67. Name the structure that connects the ear with the pharynx.
   a. Eustachian  
   b. ocular tube  
   c. pinna  
   d. cochlea

68. Which structure is found in the stapes of the middle ear?
   a. cochlea  
   b. pinna  
   c. stapes  
   d. Eustachian
69. Multiple Ribs that attach to a single cartilage and then to the sternum are called _____.
   a. true
   b. false
   c. floating
   d. attached

70. Blood cell formation occurs in the ________ system.
   a. nervous
   b. skeletal
   c. muscular
   d. senses

71. The pubic arch of an average male is _____.
   a. greater than 90 degrees
   b. greater than 360 degrees
   c. 98.6 degrees
   d. smaller than 90 degrees

72. What is the inflammation of a bursa usually caused by a blow or friction?
   a. arthritis
   b. tendonitis
   c. ligaments
   d. bursitis

73. Olfactory nerve damage would probably affect your ability to
   a. smell
   b. feel pain
   c. taste
   d. hear

74. What are the inflammatory or degenerative diseases of joints?
   a. arthritis
   b. tendonitis
   c. ligaments
   d. bursitis

75. Which is not a cardiac muscle characteristic?
   a. striations
   b. intercalated disc
   c. voluntary
   d. all are characteristics

76. The joint at the shoulder is ________.
   a. immovable
   b. slightly movable
   c. freely movable
77. Rheumatoid arthritis is a _____disease?
   a. muscle
   b. eye
   c. liver
   d. autoimmune

78. When the immune system attacks the joints it is called _______.
   a. rheumatoid arthritis
   b. rheumatoid tendonitis
   c. ligaments
   d. muscular bursitis

79. Name the gap between nerve and muscle.
   a. synaptic cleft
   b. synaptic vesicles
   c. acetylcholine
   d. axon terminal

80. Which is not a function of the skeletal muscle?
   a. Produce movement
   b. Maintain posture
   c. open up calcium
   d. generate heat

81. What provide electrical insulation to help increase the rate of impulse conduction:
   a. neurotransmitter cleft
   b. generate ATP
   c. glycogen in the muscle
   d. myelin sheath

82. Which is not the result of increased muscle use?
   a. Increase in muscle size
   b. Increase in muscle strength
   c. Increase in muscle efficiency
   d. increase in the number of muscle cells

83. Which is the contractile unit of a muscle fiber?
   a. myosin
   b. actin
   c. sarcomere
   d. none of the above
84. Neuron cells are specialized to __________?  
a. move muscle  
b. move bone  
c. transmit messages  
d. none of the above

85. Which is a function of the medulla oblongata?  
a. Heart rate  
b. Blood pressure  
c. Breathing  
d. all of the above

86. Which is a function of the Cerebellum?  
a. muscle coordination  
b. hearing coordination  
c. vision  
d. heart beat

87. Protection of the Central Nervous System is by which?  
a. Scalp  
b. Skull and vertebral column  
c. biceps  
d. carpals

88. Sympathetic nervous system is responsible for _____.  
a. fight-or-flight  
b. heat regulation  
c. thinking  
d. eye movements

89. The parasympathetic nervous system is responsible for _______.  
a. heat regulation  
b. rest and digest  
c. thinking  
d. eye movements

90. Which is considered a slight brain injury?  
a. Contusion  
b. Concussion  
c. Stroke  
d. Alzheimer’s

91. When blood flow is blocked or interrupted and brain tissue dies this is called _____.  
a. Contusion  
b. Concussion  
c. Stroke  
d. Alzheimer’s
92. Bruising blood leaking from vessels in the brain is called _________.
   a. Contusion
   b. Concussion
   c. Stroke
   d. Alzheimer’s

93. The blind spot in the eye is caused by the _____.
   a. entry of rods
   b. entry of arteries and veins
   c. entry of light
   d. cornea thickness

94. Sounds travels into the ear through the _______.
   a. External ear tube
   b. External ear folds
   c. External auditory canal
   d. none of the above

95. Which is part of the central nervous system?
   a. brain
   b. spinal cord
   c. nerves of the hand
   d. both A and B

96. Chemicals must be dissolved in mucus for detection by the _______ nerve.
   a. optic
   b. nasal
   c. smell
   d. olfactory

97. Which is not a location of the taste buds?
   a. tongue
   b. soft palate
   c. hard palate
   d. cheeks

98. Name the disease that results in the lens of the eye hardens and clouds.
   a. cataracts
   b. glaucoma
   c. astigmatism
   d. vertigo

162
99. The feeling that the person or the surroundings are spinning or whirling when there is no actual motion is called _________.
   a. cataracts  
   b. glaucoma  
   c. astigmatism  
   d. vertigo

100. Pink eye is called _____.
   a. myopia  
   b. hyperopia  
   c. strabismus  
   d. conjunctivitis
APPENDIX E
LAB SCHEDULE
<table>
<thead>
<tr>
<th>Lab #</th>
<th>Title</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction; Lab Safety</td>
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<tr>
<td>2</td>
<td>Microscope; Begin Tissues</td>
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<tr>
<td>3</td>
<td>Tissues; Start Human Body</td>
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<td>Rat Dissection; Human Body and Orientation (GG)</td>
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<td>Cell Structures,</td>
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<td>Lab Practical I</td>
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<td>8</td>
<td>Bones and Joints</td>
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<td>Axial and Appendicular Skeletons</td>
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<td>Major Muscles of the Body</td>
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<td>Brain and Cranial nerves</td>
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<td>Brain Dissection (GG); Review</td>
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APPENDIX G

MOBILE GROUP SAMPLE LAB ACTIVITY
Beginning of lab the students are given the QR Code to start the activity.

bones

- http://tinyurl.com/8c6jdtu

Students scanned the QR Code and then go over the bones on the skull. They label the bones for a participation grade, and the automatic feedback provides them the correct answer for the bones.
APPENDIX H

NON-MOBILE GROUP SAMPLE LAB ACTIVITY
Beginning of lab the students are given the handout to start the activity.

Human Body Systems

Part 1

List the 11 body systems and their major organs and structures

1.____________________________________________________________________________
2.____________________________________________________________________________
3.____________________________________________________________________________
4.____________________________________________________________________________
5.____________________________________________________________________________
6.____________________________________________________________________________
7.____________________________________________________________________________
8.____________________________________________________________________________
9.____________________________________________________________________________
10._____________________________________________________________________________
11._____________________________________________________________________________
Part 2

Place the structure or organ with the correct system (some are used more than once)

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<tr>
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<tr>
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<td>ear</td>
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</table>

**Systems:** cardiovascular muscular integumentary skeletal lymphatic endocrine nervous respiratory digestive urinary reproductive
APPENDIX I

SAFETY GUIDELINES FOR USING MOBILE DEVICES IN LAB
• Do not photograph while wearing gloves that may have worked with contaminated materials.

• If you or your device comes in contact with any potential contaminated material contact the instructor immediately.

• Always keep your personal items and mobile devices away from the experiments or lab sink.

• When working on experiments with your lab partner, have them document and take images of the lab work. Then send you a digital copy. Do not use your mobile device with contaminated gloves.

• When help is not readily available, clean up or remove any chemicals, hazardous, or contaminated materials. After your hands are washed, you can use your mobile device to document or share your lab results online.
APPENDIX K

SAMPLE LAB QUIZ AND EXAM
Sample Quiz

1. Which is not a bone of the Appendicular skeleton?
   a. carpals b. tibia c. tarsals d. rib

2. Which is a bone of the hand?
   a. metacarpals b. occipital c. lumbar d. maxilla

3. Which is a bone of the back?
   a. metacarpals b. occipital c. lumbar d. maxilla

4. Which is a bone of the leg?
   a. phalanges b. nasal c. scapula d. patella

5. Which is a bone of the head?
   a. phalanges b. tibia c. scapula d. occipital

6. Which is a bone of leg?
   a. mandible b. metatarsals c. femur d. lumbar

7. Which is a bone of neck?
   a. mandible b. metatarsals c. patella d. cervical

8. Which is not a bone of the Appendicular skeleton?
   a. radius b. tarsals c. femur d. cervical

9. Which is a bone of the leg?
   a. Humerus b. femur c. frontal d. mandible

10. Which is a bone of the Axial skeleton?
    a. Humerus b. fibula c. patella d. temporal
1. Identify
A. High power objective  B. low power objective  C. nosepiece  D. Parfocal

2. Identify
A. Fine tune adjustment knob  B. coarse adjustment knob
C. mechanical stage  D. light regulation
3. Name the Tissue

A. Simple cuboidal
B. Simple columnar
C. Pseudostratified
D. Stratified squamous

4. Name the Organelle at the tip of the red pointer
A. Rough ER
B. Golgi apparatus
C. Nucleus
D. Mitochondrion

5. Name the tissue at the tip of the red pointer.
a. Dense
d. Bone
b. Cartilage
c. Adipose
6. Identify the Tissue Type
A. Epithelial
B. Connective
C. Muscle
D. Nervous

7. In this experiment, the egg represented a/an
A. Organ
B. Organ system
C. Atom
D. Molecule
E. Cell

8. Identify the type of tissue
A. Adipose
B. Cartilage
C. Epithelial
D. None of these

9. Identify the organ
A. Heart
B. Lung
C. Stomach
D. Spleen
E. Liver
10. Identify the structure at the tip of the pointer.
   Sebaceous gland
   a. Sweat gland
   b. Arrector pilis muscle
   c. Hair follicle
   d. Pacinian corpuscle

11. Group of cells with similar structure and function are called _____.
   a. Humerus
   b. Atoms
   c. Tissues
   d. Tibia

12. Identify the part of the microscope.
   A. Fine adjustment
   B. Light control
   C. Course adjustment
   D. Stage

13. Identify the part of the microscope.
   A. Fine adjustment
   B. Light control
   C. Course adjustment
   D. Stage
14. Which is total magnification?
   a. (Final – initial) / initial
   b. Ocular X Ocular
   c. Working distance
   d. Ocular X Objective

15. Identify the structure
   A. plasma membrane
   B. nuclei
   C. cell wall
   D. None of the above

16. The closest fire extinguisher is located
   a. in the front of our lab classroom
   b. in the back of our lab classroom
   c. in the central "Prep" room
   d. in the hallway

17. The closest designated outside safety location in case of evacuation.
   a. in our lab classroom
   b. in the instructor's office
   c. Out the back door and across the street
   d. By the oil derrick
18. Name this structure?
A. Make proteins
B. Photosynthesis
C. Distribution
D. Nucleus
E. None of the above

19. What layer of the skin protects against desiccation
a. dermis
b. fat
c. epidermis
d. hypodermis

20. What was used in the sugar and water experiment?
A. microscope
B. Dialysis
C. Plasmolysis
D. Egg

21. In this set up, the cell contains 1% sugar and the test tube contains 50% sugar. With the passage of time, you would expect the cell to:
A. increase in weight
B. stay the same
C. decrease in weight
22. Identify
   a. Small intestines
   b. Spleen
   c. Large intestine
   d. Thymus

23. Identify
   a. Small intestines
   b. Spleen
   c. Large intestine
   d. Thymus

24. Identify
   A. Small intestine
   B. Large intestine
   C. Stomach
   D. Spleen

25. Identify
   A. Ovaries
   B. Uterine horns
   C. Ureters
   D. Spleen
26. Identify
   a. Small intestines
   b. Spleen
   c. Thymus
   d. Trachea

27. What are these 4 silver parts of the microscope called?
   A. Oculars
   B. Objectives
   C. Lenses
   D. None of the above

28. Which is used to clean the lens of the microscope?
   a. Kimwipe
   b. Distilled water
   c. Paper towel and windex
   d. None of the above
29. Identify this structure
A. Cell wall
B. Plasma membrane
C. Nucleus
D. RER

30. What is the function of this structure in #29?
A. Control and genetics
B. Segregate interior of cell from environment
C. Site of ATP production
D. Digestion of incoming food particles

31. Name the functions of this part of the microscope.
A. Focus
B. Change magnification
C. Adjust light
D. Position slide

32. When you change from one objective to the next the microscope stays in focus. This is called____.
A. Paracentric
B. Working distance
C. Parfocal
D. Focal change
33. What is the function?
A. Focus
B. Change magnification
C. Adjust light
D. Position slide

34.

35. Group of cells with similar structure and function are called ____
   a. Humerus
   b. Molecules
   c. Tissues
   d. Organelles
36. What part is found in the nucleus?
   a. Mitochondria  b. Cell membrane
   c. Lysosomes     d. Nucleolus

37. What is the name of the layer of epidermis above the stratum spinosum?
   a. Lucidium      b. corneum
   c. Granulosum    d. dermis

38 & 39 Identify the layer of the skin
   a. Hypodermis
   b. Epidermis
   c. Dermis
   d. None of the above
40.

41. The safety shower is located
   a. in the front of our lab classroom
   b. in the back of our lab classroom
   c. in the central “Prep” room
   d. Near elevator

42. Where is the eye wash located?
   a. back of lab
   b. middle of lab
   c. front of lab
   d. Near elevator

43. Identify
   Stratum granulosum
   b. Stratum basale
   c. Stratum corneum
   d. Stratum lucidum

44. What is a function of this tissue?
   a. Waterproof and protect against abrasions
   b. Absorption of nutrients
   c. movement

45. Which is function of the rough endoplasmic reticulum?
   a. Cell control
   b. protein synthesis
   c. remove old cellular material
   d. mitotic division

46. Smooth Endoplasmic Reticulum is the site of ____ synthesis.
   A. DNA
   B. lipid
   C. digestive enzymes
   D. oxygen
47. Tissue term stratified means?
   a. one layer with flagella
   b. more than one flagella
   c. single layer of flat cells
   d. more than one layer,

48. Cells that are flat, are called ________.
   a. square
   b. columnar
   c. squamous
   d. connective

49. Name the structures in the skin for touch.
   a. dermis
   b. blood vessels
   c. nerves
   d. root

50. Sweat pores are located in the ______.
   a. dermis
   b. fat
   c. epidermis
   d. hypodermis
APPENDIX L

SURVEY QUESTIONNAIRE
Demographic Survey Questions

Please mark the level you are as a student. Undergraduate  Graduate  Other

Please indicate your current semester ________________

Gender  M / F  Age range  18-24  25-30  31-40  41-50  51-60  61+

How do you classify yourself?  African American  White, Non –Hispanic  Hispanic  Asian  Native American

Marital Status  single  married  divorced  widowed

Please mark your highest level of education. ________________

A seven-point Likert scale

Survey Items Used in the Study

Performance expectancy
PE1: I would find m-learning useful in my learning.
PE2: Using m-learning would enable me to accomplish learning activities more quickly.
PE3: Using m-learning would increase my learning productivity.
PE4: If I use m-learning, I will increase my chances of getting a better grade in class.

Effort expectancy
EE1: It would be easy for me to become skillful at using m-learning.
EE2: I would find m-learning easy to use.
EE3: Learning to operate m-learning is easy for me.

Self-management of learning
SL1: When it comes to learning and studying, I am a self-directed person.
SL2: In my studies, I am self-disciplined and find it easy to set aside reading and homework time.
SL3: I am able to manage my study time effectively and easily complete assignments on time.
SL4: In my studies, I set goals and have a high degree of initiative.

Behavioral intention to use m-learning
BI1: I intend to use m-learning in the future.
BI2: I predict I would use m-learning in the future.
BI3: If available, I plan to use m-learning in the future.

Lowenthal, J. (2010)
APPENDIX M

FOCUS GROUP INTERVIEW QUESTIONS
Interviewer Instructions

Please encourage everyone to answer the questions. If necessary ask the student to explain their answers a little more, or you may ask the student to give an example.

Read to the students

Thank you for participating in this research. Your identity will be kept anonymous. Please be respectful to each other and allow each person to answer the questions. Please explain your answers to the best of your ability. If necessary, please give an example to help explain your response.

Mr. Stowe may have a follow up question to ask at a later date.

Questions:

What are the possible benefits of using mobile technology for learning?
What are the possible challenges you could encounter in learning using mobile technology?
How could you use mobile technology to learn in this class or lab?
How could using mobile technology affect your performance in biology?
Would using mobile technology change your effort in other classes or labs?
How could you use mobile technology for learning?
If you have used mobile technology to learn in the past, when and how did you use it?
How do you think mobile learning could help you set aside time to study?
APPENDIX N

LEVENE TESTS BETWEEN LECTURE EXAMS AND INSTRUCTIONAL METHOD
<table>
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<th>Lecture Exams and Instructional Method</th>
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<td>Lect_test2</td>
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<tr>
<td>Lect_test3</td>
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*Note.* The instructional method was for Non-Mobile Group 1 and for Mobile Group 2. *p < .05.*
APPENDIX O

LEVENE TESTS BETWEEN LECTURE QUIZZES AND INSTRUCTIONAL METHOD
<table>
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*Note.* The instructional method was for non-mobile group 1 and for mobile group 2. Lecture Quizzes were not a statistically significant part of the study, and the Levene test for homogeneity did not factor into the results. *p < .05, **p < .01.*
APPENDIX P

LEVENE TESTS BETWEEN LAB EXAMS AND INSTRUCTIONAL METHOD
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<td>Lab_test3</td>
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*Note.* Lab exams average score compared to instructional method. *p < .05. **p < .01.*
APPENDIX Q

LEVENE TESTS BETWEEN LAB QUIZZES AND INSTRUCTIONAL METHOD
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*Note.* The instructional method was for non-mobile group 1 and for mobile group 2. Lab Quizzes were not a statistically significant part of the study, and the Levene test for homogeneity did not factor into the results. *p < .05 **p < .01.
APPENDIX R

LEVENE TESTS BETWEEN COMBINED EXAM AVG AND INSTRUCTIONAL METHOD
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Note. The Levene’s test of homogeneity of variance for combine exam averages and instructional method. *p < .05.
REFERENCES


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